January 1998

Volume 2

Public Review

DRAFT

Public Review Draft

CALIFORNIA WATER PLAN UPDATE

Bulletin 160-98

Volume II
January 1998

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Note to Reviewers

Here are some points to keep in mind as you read the January 1998 public review draft of Bulletin 160-98:

1. Several key documents having statewide water management significance are now circulating for public review, including the draft EIR/EIS for the CALFED Bay-Delta program, draft CVPIA Programmatic EIS, and State Water Resources Control Board draft EIR for the 1995 Bay-Delta Water Quality Control Plan. To the extent possible, we have incorporated material from these draft documents into Bulletin 160-98. However, some of our text relating to these programs is necessarily placeholder material, pending decisions about the programs' outcomes. For CALFED, for example, we have shown operations studies results for one of the alternatives, to illustrate how the program might be implemented. This placeholder material will be updated to reflect the programs' status when the final version of Bulletin 160-98 is printed.

2. SWRCB's draft EIR for the 1995 Bay-Delta Water Quality Control Plan was released just before our draft bulletin went to printing. More discussion of the EIR will be added in the final version of Bulletin 160-98. Other events occurring just as this draft was going to print include the one-year extension of the Bay-Delta Accord, release of detailed terms for San Diego - Imperial Irrigation District water transfer for public review, and Inyo County's action on the City of Los Angeles plan for dust control in Owens Valley.

3. The negotiations over California's plan to reduce its use of Colorado River water to the State's basic apportionment are continuing. Due to printing deadlines, the version of California's "4.4 Plan" described in this draft Bulletin 160-98 will lag the negotiations by about two months.

4. Numbers shown in data tables may not add due to rounding.

Chapter 7. Options for Meeting Future Water Needs in Coastal Regions of California

This chapter covers the Coastal hydrologic regions of the State: the North Coast, San Francisco Bay, Central Coast, and South Coast (Figure 7-1). These four regions make up 29 percent of the State's land area but was home to 78 percent of the State's population in 1995.

North Coast Hydrologic Region

Description of the Area

The North Coast Region comprises the Pacific Ocean coastline from Tomales Bay to the Oregon border, extending inland to the crest of coastal watersheds. The region includes all or large portions of Modoc, Siskiyou, Del Norte, Trinity, Humboldt, Mendocino, Lake, and Sonoma counties. Small areas of Shasta, Tehama, Glenn, Colusa, and Marin counties are also within the North Coast Region (see Figure 7-2).

Most of the region is comprised of rugged mountains; the dominant topographic features are the Klamath Mountains and the Coast Range. Mountain elevations range from 5,000 feet along the coast to more than 8,000 feet in the Klamath River watershed. Valley areas include the high plateau of the Klamath River basin in Modoc County, the Eureka/Arcata area, Hoopa Valley in Humboldt County, Anderson Valley, the Ukiah area, Alexander Valley, and the Santa Rosa plain.

Precipitation in the region varies depending on location and elevation. In the Modoc Plateau of the Klamath River basin, annual precipitation averages 10 inches, while higher elevation lands of the Smith River basin in Del Norte County average more than 100 inches of rain a year. The southern portion of the region is drier; Santa Rosa averages about 29 inches of rain annually.

Figure 7-1. Coastal Hydrologic Regions

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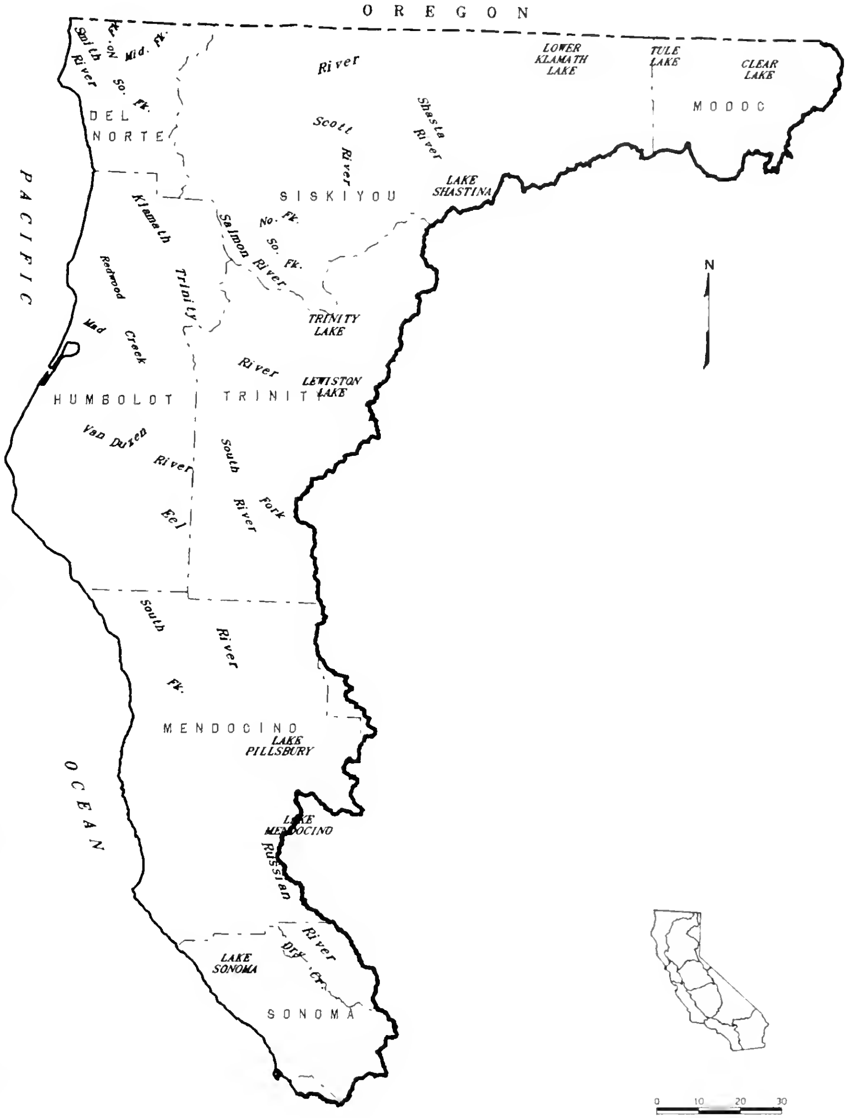
Figure 7-2. North Coast Hydrologic Region



Most land area in the North Coast Region is forest or range land. Irrigated agriculture is concentrated in the narrow river valleys such as the Russian River in Sonoma County, and on the high plateau of the Klamath River basin. The primary crops are pasture, grain, alfalfa, winegrapes, truck crops, and nursery stock. Principal cities in the region include Crescent City, Eureka, Fort Bragg, Ukiah, Santa Rosa, Mendocino and Rohnert Park. Table 7-1 shows the 1995 population and irrigated crop acreage in the region and 2020 forecasts.

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Table 7-1 . Population and Crop Acreage (in thousands)

	1995	*2020*
Population	606	835
Irrigated Crop Acres	323	335

Water Demands and Supplies

Because of the water allocated to the North Coast's wild and scenic rivers, environmental water use comprises the majority of the total water demand in the North Coast Region. Water shortages are only expected to occur under drought conditions in the North Coast Region, as shown in Table 7-2. These water shortages will be mostly in the USBR's Klamath Project's service area and some small coastal communities.

Table 7-2. North Coast Region Water Supply and Demand (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Applied Water				
Urban	169	177	201	212
Agricultural	894	973	927	1,011
Environmental	19,544	9,518	19,545	9,518
Total Applied Water	**20,607**	**10,668**	**20,672**	**10,740**
Supplies				
Surface Water	20,331	10,183	20,371	10,212
Groundwater	263	294	288	321
Recycled and/or Desalted	13	14	13	14
Total Supplies	**20,607**	**10,491**	**20,672**	**10,546**
Shortages	**0**	**177**	**0**	**194**

Three existing projects provide much of the North Coast's developed surface water supply — USBR's Klamath Project, USACE's Russian River Project, and Humboldt Bay Municipal Water District's Ruth Lake. The primary water storage facilities of USBR's Klamath Project are Upper Klamath Lake, Clear Lake, and Gerber Reservoir. This project was authorized by the Secretary of the Interior in 1905, and is one of the nation's earliest reclamation projects. The project's primary purpose is to store and divert water for agricultural use. The project service area includes more than 230,000 acres of irrigable lands in Oregon and California. The project also serves four national wildlife areas including the Lower Klamath, Tule Lake, Clear Lake, and Upper Klamath refuges.

☞Photo: one of Klamath Project dams from USBR

Lake Mendocino on the East Fork Russian River near Ukiah and Lake Sonoma on Dry Creek near Geyserville are the water storage facilities of USACE's Russian River Project. SCWA receives most of the water from this project. SCWA delivers about 29,000 af annually to Santa Rosa, Rohnert Park, Cotati, and Forestville in the North Coast Region, and another 25,000 af per year to Novato, Petaluma, the Valley of the Moon, and Sonoma in the San Francisco Bay Region. The Russian River project also regulates flow in the Russian River for agricultural, municipal, and instream uses within Mendocino and Sonoma counties, and municipal uses in Marin County. Water is imported from the Eel River into Lake Mendocino through the PG&E's Potter Valley Project.

The 48,000 af Ruth Lake is Humboldt Bay Municipal Water District's water storage facility on the Mad River. Downstream Ranney collector wells direct water that is released from Ruth Lake for distribution in the Eureka-Arcata-McKinleyville area. Humboldt Bay MWD is a water wholesaler with seven municipal, two industrial, and about 200 miscellaneous water customers. The district has been delivering water since 1962.

There is another large water development project in the North Coast -- the Trinity River Division of the CVP -- but those facilities develop supply for the Central Valley and do not deliver water in the North Coast Region. The USBR constructed Trinity River facilities in the early 1960s to augment CVP water supplies in the Sacramento and San Joaquin valleys. The principal features of the Trinity Division are Trinity Dam and the 2,477,700 af Clair Engle Lake on the upper Trinity River, Lewiston Dam, the 10.7-mile Clear Creek Tunnel beginning at Lewiston Dam and ending at Whiskeytown Lake in the Sacramento River basin, Spring Creek Tunnel, and Spring Creek Power Plant.

Exports from the Trinity River to the Sacramento River basin began in 1963. From 1980 through 1995, Trinity River exports averaged 825,000 af annually. In 1981, the Secretary of the Interior made a decision to increase instream flows in the Trinity River from 120,500 af to 286,700 af in dry years, and 340,000 af in wet years. In 1991, the Secretary of the Interior amended the 1981 decision, directing that at least 340,000 af be released into the Trinity River for water years 1992 to 1996, pending completion of a USFWS instream flow study. In 1992, CVPIA mandated that the secretarial decision remain in place until the instream flow study was

completed, at which time the study's recommendations would be implemented. Currently, the USFWS administrative review draft of the Trinity River flow evaluation report recommends that 537,000 af, 480,000 af, and 365,000 af be released in the Trinity River during normal, dry, and critically dry years, respectively.

☞Photo: Trinity Dam from USBR

Local Water Resources Management Issues

Klamath River Fishery Issues

The primary water issue in the Klamath River basin is the restoration of fish populations listed under the ESA. The Lost River and shortnose suckers have been listed under the ESA. The Lost River sucker is native to Upper Klamath Lake and its tributaries, and the shortnose sucker is found in the Lost River, Clear Lake, and Tule Lake. Both species spawn during the spring. Higher water levels in Klamath Lake may be a goal to aid recovery of these fisheries. Coho and steelhead were recently listed under the ESA. Water supply implications of the listing decisions will not be known until instream flow studies are completed and recovery goals are established.

To address competing water needs for irrigation and fishery purposes, USBR began preparing a Klamath Project Operations Plan in 1995. This planning process was originally scheduled to reach consensus on drought-year water allocation by 1996, but the difficult and complex nature of the KPOP process have delayed plan preparation. The Klamath River Basin Compact Commission is attempting to assist in developing a project operations plan. This three-member commission was established by an interstate compact ratified by Congress in 1957 to facilitate integrated management of interstate water resources and to promote intergovernmental cooperation on water allocation issues. Members include a representative from the Department, the Director of the Oregon Water Resources Department, and a presidentially-appointed federal representative.

Operation of the Klamath Project is presently in a state of flux. In 1996, USBR set an advisory water allocation schedule to maintain higher lake levels, and at the same time increased releases from Upper Klamath Lake to 1,000 cfs (290 cfs above the required minimum FERC releases of 710 cfs.) The purpose of higher Upper Klamath Lake levels was to protect the Lost

River sucker and shortnose sucker. Increased releases downstream of the Link River Dam were intended to protect salmon and steelhead populations in the Klamath River. The higher river releases and lake levels, coupled with less water in storage, impact late season irrigation deliveries to irrigators in the Klamath Project service area.

☞Photo: sucker

Trinity River Fish & Wildlife Management Program

Following completion of the Trinity River Division of the CVP in 1963, fish and wildlife populations in the Trinity River Basin declined dramatically. To reverse the fishery decline, the California Resources Agency established a statewide task force in 1967 to identify the causative factors and prescribe a corrective program. State and federal funds were budgeted to define problems, develop solutions, and begin restoring the river.

One of the most significant problems identified was the inflow of decomposed granitic sand from Grass Valley Creek. In September 1980, Congress passed Public Law 96-335, which authorized construction of Buckhorn Mountain Debris Dam on Grass Valley Creek and sediment dredging in the Trinity River below Grass Valley Creek. In September 1982, a 5-year sediment dredging agreement was signed by DFG, DWR, and USBR. This agreement provided that the Department would be responsible for all work related to sediment dredging until October 1988 and after that, the Department would continue to perform this work under contract to USBR.

In 1983, the Secretary of the Interior increased downstream releases from Lewiston Dam to improve fishery habitat and allow the USFWS to conduct a 12-year instream flow study, which was originally scheduled to end in 1996.

In October 1984, Congress passed PL 98-541 which authorized the Trinity River Fish and Wildlife Management Program. This Act provided $57 million (excluding the Buckhorn Mountain Debris Dam on Grass Valley Creek and sediment dredging costs) to implement actions needed to restore fish and wildlife populations in the Trinity River Basin to pre-project levels. In 1993, an additional $15 million was authorized for the purchase of 17,000 acres of the Grass Valley Creek watershed and its restoration.

Congress passed PL 104-143 in 1996, which extended the program three years from its original termination date to September 30, 1998, to allow expenditure of funds previously

authorized, but not yet appropriated. The Indian Self-Determination and Education Assistance Act (PL 93-638) has recently become an important part of the Trinity River Program. Three Indian tribes have indicated they want to participate in the program under the rules of this Act, which basically establish a government-to-government relationship between the tribes and the federal government.

Further reauthorization the Trinity River Fish & Wildlife Management Program is currently under consideration. A draft environmental impact statement is being prepared which will deal with proposed streamflow changes and mainstem Trinity River restoration actions.

Small Coastal Communities

The town of Klamath in Del Norte County obtains its water supply from two wells adjacent to the Klamath River. During the recent drought, Klamath Community Services District wells experienced seawater intrusion, forcing the district to use an upstream private well in the Hoop Creek drainage area. All of Klamath's water supply in 1995 was obtained from the private well, and no water was pumped from the Klamath CSD's wells. In 1996, Klamath CSD pumped adequate supplies from its two wells, but seawater intrusion during dry years remains a problem. Although the Hoop Creek drainage area has adequate groundwater supplies, Klamath CSD does not have funding to construct an additional well.

The town of Smith River, 13 miles north of Crescent City, gets its water supply from wells along Rowdy Creek. The town is experiencing spill-over growth from Brookings, a popular retirement and resort community on the Oregon Coast, about 7 miles north of the California-Oregon border. Water demands in the town of Smith River are expected to exceed the capacity of the town's delivery system if projected growth occurs. There are no plans to upgrade Smith River's water system.

Growth in the Crescent City area created the need to expand the city's water distribution system, which consists of a Ranney collector well and pump station on the Smith River to a 50,000 gallon storage tank. The Ranney collector can produce about 7,800 af, but the capacity of the existing transmission and storage system is only about 4,500 af. Crescent City is planning to add new mains, a new pump station, one additional booster pump, and a 4-mgd storage tank. The upgraded system will produce 5,900 af. The estimated cost is $6.74 million. A second

phase will make additional distribution system improvements. These new conveyance facilities should meet the city's demands through 2007.

The Weaverville Community Services District in Trinity County serves about 1,370 metered connections. In average water years, demands within the district are met with existing supplies from East and West Weaver creeks. During drought years, water rationing and building moratoria were needed to reduce demands. In response to drought year demands, a new diversion of up to 3 cfs from the Trinity River was constructed. The Weaverville area is expected to have adequate water supplies to meet demands over the next 30 years.

Trinity County Water Works District #1 is investigating a wastewater treatment and reuse project for the Hayfork area. The project would treat wastewater currently disposed of by individual septic systems. This project would eliminate septic tank seepage into local streams and provide infrastructure needed for new industries which might locate in the Hayfork Valley. The district's feasibility study identified a gravity collection system with a six acre oxidation pond and two smaller marsh areas as the best alternative for wastewater treatment. The project would treat 160 af annually, and has an option to reuse the treated water for irrigate agricultural lands or landscaping. The estimated cost for this project is $8,885,000.

The City of Rio Dell obtains its water from a well on property owned by the Eel River Saw Mill. Pentachlorophenol has been detected in groundwater on the saw mill's property, although not in the city's well water. Rio Dell is planning to find an alternate water supply. The most likely alternative will be treated surface water from the Eel River.

The City of Fort Bragg experiences water shortages during drought years. The main water sources for the city are direct diversions from the Noyo River, Newman Reservoir, and Waterfall Gulch south of Highway 20. During average rainfall years, water rights from these three sources are enough to meet the city's demands to the year 2020. However, supplies are inadequate to meet the city's needs during drought years while maintaining instream fish flows required by DFG. Due to drought year shortages, DHS issued an order in 1991 prohibiting new demands on the water system until adequate water supplies were developed. The city has been investigating alternate sources of supply in addition to implementing water conservation measures and improving existing system capacity. As a result of these corrective measures, DHS lifted its

order in 1993 and allowed the city to begin issuing building permits and making other commitments for water connections.

In some smaller communities along the coast, groundwater use is constrained by limitations in aquifer storage capacity. Wells on low terraces near the ocean are potentially vulnerable to seawater intrusion. The town of Mendocino is completely dependent on individual wells. A local survey conducted in 1986 showed that about 10 percent of the wells go dry every year and 40 percent go dry during drought years. In 1986, water was trucked in during summer and fall to help alleviate chronic shortages. The Mendocino City Community Services District investigated a new water supply sources, including new wells in the Big River aquifer and desalination. To date, no acceptable water source has been identified. In 1990, town residents approved developing a public water system if an adequate water source could be found. The district is currently collecting hydrogeological data of the basin.

Russian River Environmental Restoration Actions

Water quality issues and barriers to fish migration in the Russian River are of concern in this river basin. No future water supply shortages are forecasted for the river basin, although actions taken to protect recently listed salmonids may affect existing or future diversions. A *Russian River Action Plan*, prepared by the SCWA in 1997, provides a regional assessment of needs in the watershed and identifies a fishery habitat restoration projects in need of funding. The SWRCB is promoting a coordinated Russian River fishery restoration plan. The impacts of recent ESA listing of coho and steelhead on water diversions have not yet been established.

The Eel-Russian River Commission, made up of county supervisors from Humboldt, Mendocino, Sonoma, and Lake counties, provides a regional forum for agencies and groups to stay informed about projects and issues affecting the Eel and Russian rivers. The Commission was formed in 1978, under a joint powers agreement among the counties, to aid in implementation of an Eel-Russian River watershed conservation and development plan. A regional issue currently being addressed by the commission is the review of a draft 10-year fishery study by PG&E for its Potter Valley Project, required as a condition of a 1983 FERC license.

A project proposed by SCWA would allow fish passage through a flood control structure on Matanzas Creek in downtown Santa Rosa. The original structure, constructed in the early 1960s for flood control, does not permit fish passage. SCWA also proposes to install a fish ladder at Healdsburg Dam on the main stem of the Russian River, a small flashboard dam used in the summer to create a recreational pool.

Improving Russian River Quality

The City of Santa Rosa is expanding its wastewater reclamation program by exploring alternatives to discharging treated wastewater into the Russian River. These alternatives include two options for using wastewater for irrigation projects and a third option for recharging depleted geothermal fields in the Geysers area. Because the water discharged to the Russian River would have been reused downstream, these options are not being considered to produce a new water supply.

The lower Russian River area has several unincorporated communities that do not have community sewerage systems. These communities use on-site wastewater collection, treatment and disposal systems, such as septic tanks. Construction of a transmission pipeline to connect the communities to existing treatment plants, and the construction of community leachfields, is being evaluated.

SCWA Water Supply and Transmission Project

SCWA is proposing a project to develop additional water supply and expand its existing transmission system. Project components consist of water conservation, increased use of the Russian River Project, and an aquifer storage and recovery program (to meet emergency and standby water supply needs).

Potter Valley Project

PG&E's Potter Valley Project diverts water from the Eel River to the East Fork of the Russian River for power generation and downstream agricultural and municipal water use The project consists of Scott Dam and Lake Pillsbury, Van Arsdale Diversion Dam and tunnel, and the Potter Valley Power Plant. The project diverts about 159,000 af of water and generates about 60 million kilowatts-hours of energy. Releases are limited by required minimum flows on the Eel River and by requirements to maintain reservoir levels during the summer recreation season

in Lake Pillsbury. PG&E is trying to secure additional operating revenue from the project and, if unsuccessful, may sell, or abandon the project. Local agencies have expressed interest in acquiring the project if it were to be sold.

Water Management Options for the North Coast Region

Table 7-3 shows a comprehensive list of options for this region, and the results of an initial screening of the options. The retained options were evaluated (see Table 7A-1 in Appendix 7A) based on a set of fixed criteria as discussed in Chapter 6. The results of the evaluation are shown in Table 7-4.

Table 7-3. North Coast Region Comprehensive List of Water Management Options

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to $0.8ET_o$	Retain	
	Residential Indoor Water Use	Defer	A low level of water use has already been achieved.
	Interior CII Water Use	Retain	
	Distribution System Losses	Defer	No substantial depletion reductions attainable.
Agricultural			
	Seasonal Application Efficiency Improvements	Defer	No substantial depletion reductions attainable.
	Flexible Water Delivery	Defer	No substantial depletion reductions attainable.
	Canal Lining and Piping	Defer	No substantial depletion reductions attainable.
	Tailwater Recovery	Defer	No substantial depletion reductions attainable.
Modify Existing Reservoirs/Operations			
	Ewing Reservoir Enlargement	Defer	No demand for additional supply
New Reservoirs/Conveyance Facilities			
	Boundary Reservoir - Lost River	Defer	Low yields, high cost.
	Beatty Reservoir - Sprague River	Defer	High cost, indian archaeology and sucker habitat are concerns.
	Chiloquin Narrows Reservoir - Sprague River	Defer	High cost, indian archaeology and sucker habitat are concerns.
	Montague Reservoir - Shasta River	Defer	Low yields, high cost.
	Grenada Ranch Reservoir - Little Shasta River	Defer	Low yields, poor dam site and reservoir geology, high cost.
	Table Rock Reservoir - Little Shasta River	Defer	No surplus water, no local interest.
	Highland Reservoir - Moffett Creek	Defer	Low yields, high cost.
	Callahan Reservoir - Scott River	Defer	Low yields, high cost, no local interest.
	Grouse Creek Reservoir - E.F. Scott River	Defer	Reservoir seepage a problem, high cost, no local interest.
	Etna Reservoir - French Creek	Defer	Low yields, high cost, no local interest.
	Mugginsville Reservoir - Mill Creek	Defer	Low yields, excessive cost.
	Various sites in Noyo/Navarro River Basins	Defer	No local interest in off-stream storage; unfavorable environmental conditions
	Long/Round/Aspen Valley Reservoirs - Klamath River	Defer	Excessive capital cost, questionable reservoir geology.
	Georgia-Pacific Wood Waste Disposal Site	Defer	Site not available
	Georgia-Pacific Replacement Site	Defer	Unfavorable geotechnical conditions.
	Georgia-Pacific Site No. 3	Defer	Unfavorable geotechnical conditions.
	Newman Gulch Site	Defer	Unfavorable geotechnical conditions.
	Large reservoir at Boddy Property Site	Defer	Excessive capital cost.
	Smaller reservoir (at Boddy property site or alternate location)	Retain	

Table 7-3. Continued

Waterfall Gulch Intake Improvement	Retain	
South Basin (City of Fort Bragg)	Retain	
Groundwater/Conjunctive Use		
New wells	Retain	
Water Transfers/Banking/Exchange		
-----	-----	-----
Water Recycling		
City of Fort Bragg	Defer	Unfavorable costs
Desalination		
Brackish Groundwater		
City of Fort Bragg Project	Retain	
Seawater		
City of Fort Bragg Project	Retain	
Other Local Options		
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Statewide Options		
-----	-----	-----

Table 7-4. Ranking Options for the North Coast Hydrologic Region

Option	Rank	Cost per af ($)	Potential Gain (taf) Avg	Potential Gain (taf) Drt
Conservation				
Urban				
Outdoor Water Use - New Development	M	750	2	2
Outdoor Water Use -New and Existing Development	L	*	10	10
Interior CII Water Use (2%)	M	500	2	2
Interior CII Water Use (3%)	L	750	3	3
New Reservoirs/Conveyance Facilities				
Smaller Reservoir (@ Boddy property site or alternate location)	L	980	1	1
Waterfall Gulch Intake Improvement	M	330	**	**
South Basin (City of Fort Bragg)	M	380	**	**
Groundwater/Conjunctive Use				
New wells - Fort Bragg and other small Coastal Communities	H	110	**	**
Agricultural Groundwater Development	M	*	*	*
Desalination				
Brackish Groundwater				
City of Fort Bragg Project	M	770	-	1
Seawater				
City of Fort Bragg Project	M	4,400	-	1

* Data not available.

** Less than 1,000 af.

Water Conservation

Urban. The urban water supply forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. All urban conservation options except reducing residential interior water use were retained. The later option was deferred because interior water use has, on average, already attained the levels evaluated in the Bulletin for future water management options. Reducing outdoor water use to 0.8 ET_0 in new development would attain about 2 taf per year of depletion reductions, while extending this measure to include existing development would reduce depletions by about 10 taf per year. Reducing commercial and industrial water use an additional 2 percent and 3 percent would attain 2 and 3 taf per year of depletion reductions, respectively. There is less than 1 taf of depletion reductions attainable with reduction in distribution system losses.

Agricultural. Agricultural conservation options were deferred from evaluation because there is little potential to create new water (reduce depletions) from them in the North Coast Region.

Modifying Existing Reservoirs or Operations

Trinity County Works District #1 has considered raising Ewing Dam. The dam was designed to be raised up to 12 feet to meet future water supply needs, increasing reservoir capacity from 800 af to 1,450 af. Raising the dam 12 feet and modifying the spillway and outlet works would cost $1.5 million. Plans to enlarge the reservoir were halted when a local lumber mill, the primary employer in Hayfork, closed, reducing the district's customer base by about 10 percent.

New Reservoirs and Conveyance Facilities

Onstream Storage. Eleven onstream reservoirs in the Klamath River basin were evaluated and deferred, mainly because of high costs and relatively low yields. Cursory investigations of these projects were completed by USBR, the Department, or the Oregon State Water Resources Board. Recent studies completed by the City of Fort Bragg identified potential onstream reservoir sites in the Noyo River watershed; however, these sites were deferred due to environmental and economic concerns.

Offstream Storage. USBR investigated three offstream reservoirs in Oregon's Long, Aspen, and Round valleys adjacent to Upper Klamath Lake. These offstream storage plans were deferred due to excessive capital costs and the subsequent high cost for stored water.

In 1993, the City of Fort Bragg moved forward with preliminary plans and an environmental impact report on its preferred long-term project, which included a 1,500 af offstream reservoir. The most promising location for the storage facility was the Georgia-Pacific Wood Waste Disposal site, which was being considered for closure. However, the company decided not to close the site. The city investigated other locations, but geotechnical investigations indicated that all except one of the sites was unsuitable. The most promising reservoir site, on the Boddy property, would store water pumped from the Noyo River during winter high flows. The water would be used during the summer months when the city cannot divert water and meet bypass flow requirements. The project originally envisioned was deferred due to high capital costs. A smaller reservoir (about 1,000 af at this or an alternate site) was evaluated.

Conveyance Facilities. The City of Fort Bragg is investigating alternatives that could provide smaller amounts of additional water to help meet short-term needs. The city's diversion from Waterfall Gulch could be improved to capture an additional 110 af per year by lowering the intake structure. The city has also identified a number of small surface sources in the South Basin area. One location has significant flows in the season and could provide about 200 af per year. The city has initiated discussions with the Harbor District who owns the property where the diversion would be located.

Groundwater and Conjunctive Use

Surface water sources meet most of the water needs in the coastal regions. Communities with water shortage problems continue to look for possible groundwater sources and well locations to provide adequate supplies at reasonable cost. Although groundwater quality is generally good, supplies are limited by aquifer storage capacity. For example, Fort Bragg began a test program in 1994 to identify possible well sites that could produce about 400 af in drought years.

Water Recycling

The City of Fort Bragg had considered a water reclamation project which involved using tertiary treated wastewater to replace the potable water used at a lumber processing plant. However, water conservation efforts by the plant since 1990 reduced its water demand by more than 50 percent, rendering this option uneconomical.

Other water recycling projects planned in the region would not generate a source of new supply from a statewide perspective. Recycling is a potentially important water source for local purposes, but does not create new water that would otherwise be lost to the hydrologic system. There are several projects planned which would produce about 15,000 af of recycled water to serve local water management needs for agricultural, environmental, and for landscape irrigation purposes.

Desalination

Interest in desalination as a long-term solution for the City of Fort Bragg increased when feasibility studies showed it was economically competitive with storage alternatives. The city evaluated two reverse osmosis alternatives -- one involving seawaters and one involving brackish water. Both plant designs would produce about 1,000 af of potable water in drought years. Major cost components for the seawater plant would include the ocean intake structure, feedwater pipeline to the plant, and processing equipment. The brackish groundwater water plant would require wells, well field collection piping, and a feedwater pipeline into the plant. The city is conducting more detailed studies to identify the location of brackish water sources and brine disposal options.

Water Resources Management Plan for North Coast Region

By 2020, shortages in the region are forecast to be 194 taf in drought years. No average year shortages are forecast in 2020. The options likely to be implemented in this region to meet shortages are limited (Table 7-5). The majority of shortages in the region are agricultural and are expected to occur in the Klamath Project. The economics of crop production have a major influence on the extent to which growers can afford to find drought year water supply improvements. Additional groundwater development is a possibility in some areas of the Klamath Project, but there are little data available to evaluate this option. The ability to change

cropping patterns in the northern part of the region is limited by the area's climatic conditions. There are no quantifiable options available in to meet agricultural shortages.

Urban water conservation options could provide 4,000 af per year in water savings. The City of Fort Bragg is investigating short- and long-term options to improve its water supply reliability. The Waterfall Gulch Intake Improvement and the South Basin Diversion are smaller, short-term options for the Fort Bragg area, which would augment the city's water supply by 300 af per year. Favorable long-term options are either an offstream storage facility or desalination project, which are not likely to be implemented in the near future. Small communities along the coast generally do not have the financial resources to construct major water supply projects, therefore they will continue to investigate new groundwater supplies.

Table 7-5. Summary of Options Most Likely to be Implemented by 2020 North Coast Region

Option	Potential Gain (taf)	
	Avg	Drt
Shortage *	*0*	*194*
Conservation	-	4
Modify Existing Reservoirs/Operations	-	-
New Reservoirs/Conveyance Facilities	**	**
Groundwater/Conjunctive Use	-	**
Water Transfers/Banking/Exchange	-	-
Recycling	-	-
Desalination	-	-
Statewide Options	-	-
Total Potential Gain	-	4
Remaining Shortage	*0*	*190*

* Majority of shortages in this region are agricultural. Most agricultural shortages in this region are expected to occur in the Klamath Project area.

** Options with less than 1,000 af of yield are not shown.

San Francisco Bay Hydrologic Region

Description of the Area

The San Francisco Bay Region (Figure 7-3) extends from southern San Mateo County north to Tomales Bay in Marin County, and inland to the confluence of the Sacramento and San Joaquin rivers near Collinsville. The eastern boundary follows the crest of the Coastal Ranges. The region includes all of San Francisco and portions of Marin, Sonoma, Napa, Solano, San Mateo, Santa Clara, Contra Costa, and Alameda counties. The San Francisco Bay Region is divided into the North Bay and South Bay planning subareas. Geographic features include the Marin and San Francisco peninsulas; San Francisco, Suisun, and San Pablo bays; and the Santa Cruz Mountains, Diablo Range, Bolinas Ridge, and Vaca Mountains of the Coastal Ranges. Streams flow into the bays or to the Pacific Ocean.

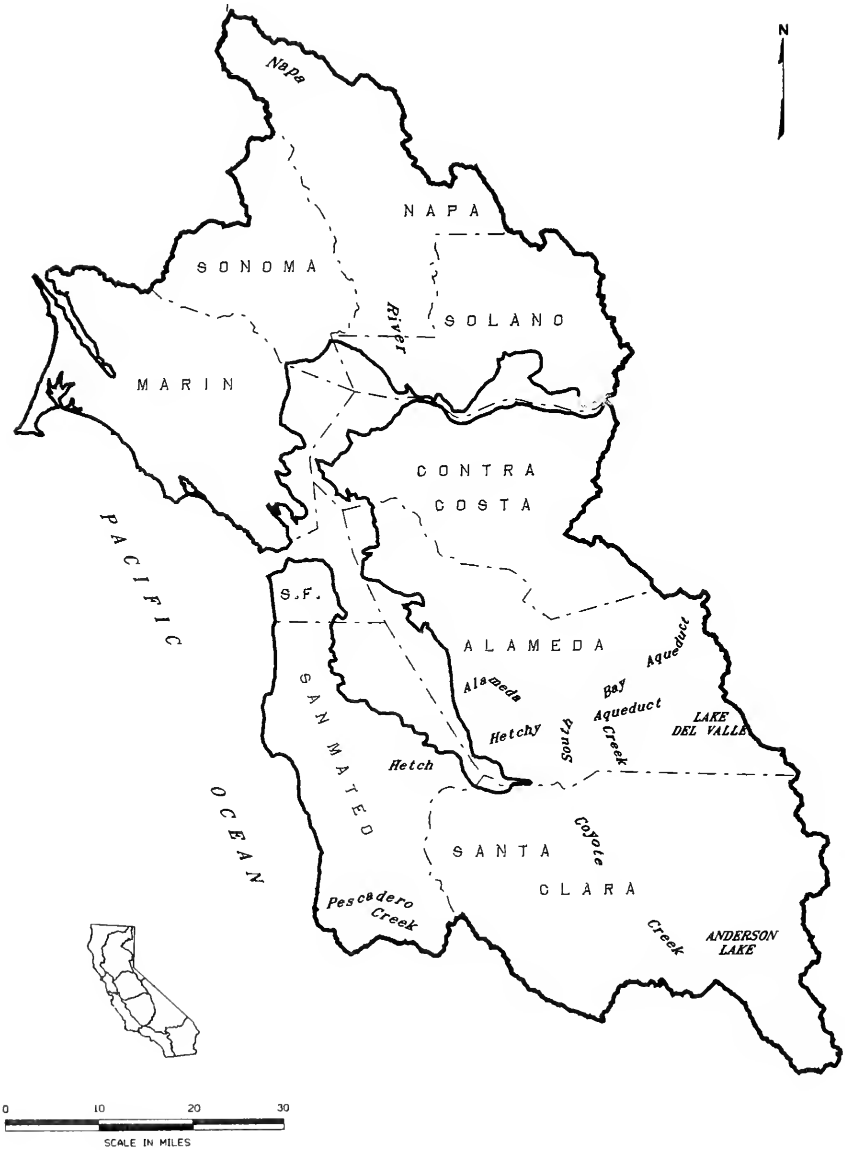
The climate within the region varies significantly from west to east. The coastal areas are typically cool and often foggy. The inland valleys and interior portions of San Francisco Bay are warmer, with a Mediterranean-like climate. Consequently, per capita water use increases from west to east. The average annual precipitation in the region is 31 inches, ranging from 13 inches in Pittsburg to 48 inches at Kentfield, below Mount Tamalpias in Marin County.

The region is highly urbanized and includes the San Francisco, Oakland, and San Jose metropolitan areas. Agricultural acreage is mostly in the north, with the predominant crop being grapes. In the south, more than half of the irrigated acres are in high-value specialty crops, such as artichokes or flowers. Table 7-6 summarizes the population and irrigated crop acreage for the region.

Table 7-6. Population and Crop Acreage (in thousands)

	1995	*2020*
Population	5,780	7,025
Irrigated Crop Acres	65	65

Figure 7-3. San Francisco Bay Hydrologic Region



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Water Demands and Supplies

Table 7-7 shows the water budget for the San Francisco Bay Region. Environmental water demands, primarily Bay-Delta outflow, account for most of the San Francisco Bay Region's water use. Water demands for Suisun Marsh are also included in environmental water needs. As shown in the table, water shortages are forecast only for drought years.

Table 7-7. San Francisco Bay Region Water Supply and Demand(taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Applied Water				
Urban	1,255	1,358	1,317	1,428
Agricultural	98	108	98	108
Environmental	5,762	4,294	5,762	4,294
Total Applied Water	7,115	5,760	7,176	5,830
Supplies				
Surface Water	7,011	5,285	7,067	5,328
Groundwater	68	92	74	91
Recycled and/or Desalted	35	35	35	35
Total Supplies	7,115	5,412	7,176	5,454
Shortages	0	349	0	376

North Bay

Municipal and industrial water use will continue to grow as the population in the North Bay grows. The fastest growing communities have been municipalities in southwestern Solano County, such as Fairfield and Benicia. Growth in the larger communities of Sonoma and Napa counties, such as Petaluma and Napa, has also been fairly rapid (more than 20 percent during the 1980s). Growth in Marin County has been slowed both by a lack of land available for development and by two water hook-up moratoriums administered by Marin Municipal Water District. The most recent moratorium was lifted in 1993 when the drought ended and a new Russian River water contract was ratified.

The Suisun Marsh is the only managed wetland in the North Bay that requires deliveries of fresh water. Its annual water demand is expected to remain constant at 150,000 af.

Table 7-8. Major North Bay Water Suppliers

Water Agency	*Primary Source of Supply*
Sonoma County Water Agency	Russian River Project
Marin Municipal Water District	Local Surface and Sonoma CWA contract
Napa Co. Flood Control & Water Cons. Dist.	Local Surface and State Water Project
Solano County Water Agency	Solano Project and SWP

Table 7-8 lists the major water suppliers within the North Bay, along with their primary sources of supply. Each of these agencies represent a number of municipalities or water retailers within their county. Groundwater and small locally developed supplies serve the remainder of the water users in the area. Table 7-9 lists local agency water supply reservoirs serving the North Bay with capacity greater than ten thousand acre feet.

Table 7-9 . Reservoirs of Local Agencies Serving the North Bay

Agency	*Reservoir*	*Capacity (af)*	*Year Constructed*	*Region Located*
COE/Sonoma CWA[1]	Lake Mendocino	118,900	1922	North Coast
COE/Sonoma CWA[1]	Lake Sonoma	381,000	1982	North Coast
Pacific Gas & Electric	Lake Pillsbury	73,000	1921	North Coast
Marin Municipal WD	Kent Lake	32,895	1953	San Francisco
Marin Municipal WD	Nicasio Res.	22,430	1960	San Francisco
Marin Municipal WD	Soulajule Res.	10,572	1979	San Francisco
City of Napa	Lake Hennessey	31,000	1946	San Francisco
City of Vallejo	Lake Curry	10,700	1926	San Francisco

[1] The Corps of Engineers built Lake Mendocino and Lake Sonoma primarily for flood control. However, SCWA paid for, operates, and holds the water rights for the water supply portion of these facilities. Water from these projects is shown in the water budgets as Local Surface in the North Coast Region and Local Import in the San Francisco Region.

- Sonoma CWA, which wholesales water throughout Sonoma and Marin counties, is forecasting no water shortages through 2020, and is not looking at water supply reliability enhancement options.

- Marin MWD was once one of the most vulnerable water suppliers in the state. However, the district negotiated a 10,000 af water supply contract with Sonoma CWA in 1991 and now expects to have a more reliable supply as it develops infrastructure to import Russian River water.

☞Photo: Napa terminal tank

- Napa County Flood Control and Water Conservation District has a contract for SWP water with a maximum entitlement of 25,000 af per year. The City and County of Napa are examining water supply enhancement options to ensure future supply reliability.
- Solano County WA anticipates a water supply deficiency as municipalities in the western part of the county continue to urbanize rapidly without developing additional water supply sources. Solano CWA's 1995 SWP supply was about 35,000 af. The agency will reach its maximum SWP supply entitlement of 42,000 af in 2015. Benicia is the most vulnerable of the agency's service areas to drought conditions because it is entirely dependent on SWP water. Fairfield also is forecasting future drought water shortages.

South Bay

The South Bay is highly urbanized—about 16 percent of the State's population lives in 2 percent of the South Bay's land area. During the 1980s, the growth rate in the South Bay was about 14 percent. The fastest growing communities in the area had been almost exclusively in the East Bay -- such as Dublin, Emeryville, and San Ramon.

A minor portion of South Bay water use is for agriculture. Hayward Marsh is the only identified environmental water use within the South Bay. The marsh, part of the Hayward Regional Shoreline, has an annual freshwater use of approximately 10,000 af of reclaimed wastewater from Union Sanitation District. Industrial water use for cooling is primarily associated with independently produced industrial water along the Carquinez Straits.

Table 7-10 lists the major water suppliers in the South Bay and their primary sources of supply. Those areas not served by the listed suppliers get their water from groundwater and from small locally developed surface supplies. Alameda County Flood Control and Water Conservation District, Zone 7, and Santa Clara Valley Water District recharge and store local and imported surface water in local groundwater basins. Each of the major water agencies represent

several municipalities or water retailers within their service areas. Table 7-11 lists all local agency surface supply reservoirs serving the North Bay with capacity greater than ten thousand acre feet.

Table 7-10. Major South Bay Water Suppliers

Water Agency	*Primary Source of Supply*
San Francisco PUC	Hetch Hetchy project and local surface
Santa Clara Valley Water District	Local surface, groundwater, CVP, and SWP
Alameda County Water District	Local surface, groundwater, SWP, and Hetch Hetchy project
Alameda CFC&WCD Zone 7	Local Surface, groundwater, and SWP
East Bay Municipal Utility District	Mokelumne River project and local surface
Contra Costa Water District	CVP and local surface

Table 7-11. Local Surface Reservoirs Serving the South Bay

Agency	*Reservoir*	*Capacity (af)*	*Year Constructed*	*Region Located*
San Francisco PUC	Lake Lloyd	273,400	1956	San Joaquin River
San Francisco PUC	Lake Eleanor	27,300	1918	San Joaquin River
San Francisco PUC	Hetch Hetchy Res.	340,830	1923	San Joaquin River
San Francisco PUC	Calaveras Res.	96,842	1925	San Francisco
San Francisco PUC	Lower Crystal Springs	58,375	1888	San Francisco
San Francisco PUC	San Andreas Res.	18,996	1870	San Francisco
San Francisco PUC	San Antonio Res.	50,496	1964	San Francisco
East Bay MUD	Camanche Res.	417,120	1963	San Joaquin River
East Bay MUD	Pardee Res.	197,950	1929	San Joaquin River
East Bay MUD	San Pablo Res.	38,600	1920	San Francisco
East Bay MUD	Briones Res.	60,510	1964	San Francisco
East Bay MUD	Chabot Res.	10,350	1892	San Francisco
East Bay MUD	Upper San Leandro Res.	41,440	1977	San Francisco
Contra Costa WD	Los Vaqueros Res.	100,000	under construction	San Joaquin River
Santa Clara Valley WD	Calero Res	10,050	1935	San Francisco
Santa Clara Valley WD	Coyote Res.	22,925	1936	San Francisco
Santa Clara Valley WD	Leroy Anderson Res.	89,073	1950	San Francisco
Santa Clara Valley WD	Lexington Res.	19,834	1953	San Francisco

- SFPUC provides water to more than 2.3 million people in San Francisco, San Mateo, Santa Clara, and Alameda counties, and is forecasting drought year shortages through 2020. In 1990 and 1991 (at the end of the recent drought), wholesale and retail customers received 25 percent rationed supplies (based on historic use). In 1991, SFPUC adopted, but did not implement a 45 percent rationing plan. Recently revised instream flow requirements in the Tuolumne River basin have reduced the available Hetch Hetchy supply. The city's studies indicate that the annual safe yield of the Hetch Hetchy system has dropped from 336,000 af to 271,000 af.

☞Photo: Crystal Springs Reservoir

- SCVWD provides water to 16 municipal and industrial retailers as well as to agricultural users in Santa Clara County. A number of these retailers also contract with San Francisco Water District for water from Hetch Hetchy. The district possesses one of the most diverse supplies in the state with imported state project and federal project water, locally developed surface supplies and extensive groundwater recharge programs. Some of the retail agencies in the district are vulnerable to drought deficiencies imposed by the SWP, CVP, and Hetch Hetchy. These deficiencies may be intensified by locally diminished runoff during drought conditions.

☞Photo: SCVWD recharge site

- ACWD serves a population of 286,000 in southwestern Alameda County, adjacent to San Francisco Bay. ACWD's Niles Cone groundwater basin supply is augmented by SWP and Hetch Hetchy supplies, which makes the district vulnerable to drought deficiencies imposed by SWP or SFPUC.
- ACFC&WCD, Zone 7 delivers water in the Livermore-Almaden Valley in eastern Alameda County, including the communities of Dublin, Livermore, and Pleasanton, as well as various agricultural and industrial customers. Zone 7 will reach its maximum SWP entitlement of 46 taf in 1997.
- EBMUD provides water to 1.2 million people in the remainder of northern Alameda County, as well as part of western portion of Contra Costa County. Virtually all of the water used by EBMUD comes from the 577-square-mile watershed of the Mokelumne

River, which collects runoff from Alpine, Amador, and Calaveras counties, on the west slope of the Sierra Nevada. EBMUD has water rights for up to 364,000 af per year from the Mokelumne River. In average years, district reservoirs in the East Bay receive an additional 30,000 af from local watershed runoff. In dry years, evaporation and other reservoir losses may exceed local runoff.

☞Photo: EBMUD Mokelumne Aqueduct in Delta

- CCWD delivers municipal and industrial water throughout eastern Contra Costa County. Drought water use in the district may actually increase, since industrial diverters along the Bay and Delta often switch to the district supply during drought conditions because of water quality constraints. The district contracted for up to 195 taf from the CVP; this contract was recently renegotiated to include operation of Los Vaqueros Reservoir, now under construction by the district. Under its new CVP contract, CCWD will receive 75 percent of the contract amount, or 85 percent of historic use, during drought periods. Under severe drought conditions, the CVP supply may be reduced to 75 percent of historic use. CCWD has a smaller locally developed source at Mallard Slough, with an associated right to take up to 26,700 af.

☞Photo: Los Vaqueros from CCWD

Small, independent water systems, such as those along the San Mateo coast, also suffer water supply reliability problems during a drought. These systems are often dependent on a single source, such as groundwater, and do not have connections to the larger systems throughout the Bay Area. Consequently, transfers are not feasible.

Local Water Resources Management Issues

Bay-Delta Estuary

. The CALFED Bay-Delta Program, charged with developing a long-term solution to Bay-Delta Estuary problems, is discussed in detail in Chapter 6. The 1995 State Water Resources Control Board *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*, which established water quality control measures to protect the beneficial uses of the Bay-Delta Estuary, is described in Chapters 2, 3, and 4. The plan includes a list of the beneficial uses of water to be protected, water quality objectives, and

an implementation program. The SWRCB is examining alternatives for achieving the water quality plan objectives. An environmental review will select a preferred alternative to allocate responsibility for Delta flows and diversions to and from the Delta. Currently, the Department and USBR—as operators of the SWP and CVP—are responsible for meeting existing standards. The Board may amend water rights for users who depend upon in-Delta supplies as well as those who divert upstream of the Delta.

Suisun Marsh

In 1995, USBR, DWR, DFG, and the Suisun Resource Conservation District began negotiations to update the Suisun Marsh Preservation Agreement. In 1996, the negotiators agreed in principle to 10 joint actions designed to lower soil salinity on Suisun Marsh managed wetlands (especially in the Marsh's western half) and to use water more efficiently. SWRCB will review western Suisun Marsh water quality objectives and water rights issues. A more detailed discussion of Suisun Marsh and other Bay-Delta environmental issues can be found in Chapters 2, 4, and 6.

Local Water Agency Issues

The primary water supply source for Sonoma County Water Agency, the Russian River, is in the North Coast Hydrologic Region. Issues related to SCWA and the Russian River are discussed in the North Coast Region portion of this chapter. Issues facing other major water suppliers in the North Bay are discussed below.

In 1995, the SWRCB issued Decision WR 95-17, which designates instream flow requirements in the Lagunitas Creek watershed. Marin Municipal Water District estimates that the decision will diminish its system supply by 3,000 af annually during drought years. In the past, MMWD had examined desalination as an option to augment its water supply, studying construction of a 10 mgd reverse osmosis desalination plant near the western end of the San Rafael Bridge. The plant's yield would be approximately 10 taf at a cost of $1,900 per af. The desalination project was included in a 1991 bond measure that was not approved by the voters. The following year, a bond measure for new facilities to bring more Russian River water to Marin passed, and MMWD's need for the desalination option diminished. The new MMWD

Russian River facilities will be on line by 2020. Since the district has all the necessary permits, this new water is not listed as an option but is included in its base supply.

USBR and Solano County Water Agency have been involved in water rights disputes for Putah Creek both upstream and downstream of USBR's Solano Project facilities. In 1995, a settlement agreement was reached with water users in Lake and Napa counties upstream of Lake Berryessa. The agreement establishes limits on future water development in the Lake Berryessa watershed and allocates water use for the upstream users. A court appointed watermaster will monitor water uses and enforce the terms of the settlement agreement.

Downstream of the Solano Project, disputes are centered around environmental water use and riparian water rights. The Putah Creek Council brought a suit in 1990 against Solano Project water users to increase flows in the lower reaches of the creek. In 1996, the Sacramento County Superior Court ruled on instream flow requirements for Putah Creek downstream from Solano Diversion Dam, where water is diverted to Putah South Canal for delivery to agricultural lands and to communities in Solano County. The judgment cites the public trust doctrine as well as California Fish and Game code requirements and requires higher (and year-round) flows from the creek into the Yolo Bypass. SCWA estimates the additional requirements are approximately 10,000 acre feet during an average year and 20,000 acre feet during a dry year. Solano County interests are appealing the judgment, which has been stayed until the case is heard by the State Appellate Court. Meanwhile, USBR is seeking an out-of-court settlement of the case. Under the Superior Court judgment, Solano County water users would be responsible for meeting the instream flow requirements in the downstream portion of the creek. Solano County water users have asked the SWRCB to participate in the settlement process so that regulation of riparian diversions can be included in the final instream flow requirements for the creek.

SCWA's contract with USBR for the Solano Project water supply will expire in 1999. The contract is renewable, but the terms and conditions of the contract will be renegotiated. SCWA will then need to renegotiate its contracts with Solano Project member units.

Solano County water agencies are monitoring use of groundwater from the Putah Fan/Tehama Formation groundwater basin because of concerns about the condition of the shared basin. The City of Vacaville, Solano Irrigation District, Maine Prairie Water District, and

Reclamation District 2068 have all implemented AB 3030 groundwater management plans. SCWA has initiated a groundwater monitoring and data collection program and will prepare an annual groundwater report to be used by the agencies in making decisions about the basin. In addition, Vacaville, SID, Dixon, and Solano County developed a 1995 agreement to cooperatively mitigate any adverse conditions related to the basin.

Alameda County Water District is continuing to monitor and manage saline water intrusion in its bayside aquifers. The district is dependent upon the Niles Cone Groundwater Basin, which includes at least three distinct aquifers, for district supplies. The district recharges locally developed water and imported surface water to the basin and extracts recharged supplies from the basin. Prior to the 1960s, when ACWD began importing surface supplies, the upper two aquifers were overpumped, causing saline intrusion into the basin. In 1974, ACWD began its aquifer reclamation program, which includes nine wells designed to pump and discharge saline groundwater from the basin. Because of further intrusion of saline water during the recent drought, ARP operations have been modified to pump and dispose of more saline water than had been thought necessary. In 1992, a reconnaissance level study was conducted to evaluate the feasibility of desalting water pumped from ARP wells and blending it with groundwater and imported surface water. This desalination option is discussed in the following option evaluation section.

The district is also developing a groundwater model to simulate the effectiveness of ARP, movement of saline water, and remediation of the basin. Careful management of the basin, including water level and water quality monitoring, is designed to protect the integrity of the groundwater resource and maintain efficient use of imported supplies.

ACWD entered into a one-year agreement in 1996 with Semitropic Water Storage District to transfer up to 6,700 af of water to Semitropic as part of an in-lieu groundwater recharge program. The agreement provides for the return of ACWD's stored water during drought years through groundwater extraction. ACWD recently completed a long-term transfer and banking agreement for 50,000 af of storage in Semitropic's basin.

San Francisco Public Utility Commission and the Bay Area Water Users Association (SFPUC Bay Area Water contractors) are cooperatively developing a water supply master plan

for the PUC's retail and wholesale service areas. Phase 1 of the three-phased plan was recently completed. The preliminary list of water supply options to be considered in Phase 2 includes:

- short- and long-term Central Valley water transfers
- conjunctive use / groundwater banking within the Hetch Hetchy system (Tuolumne River basin and areas adjacent to the aqueduct alignment)
- transfers within the Hetch Hetchy system
- additional surface storage within the Hetch Hetchy system
- conjunctive use / groundwater banking within the Bay Area system
- transfers within the Bay Area system
- additional surface storage within the Bay Area system
- desalination
- other local projects

Phase 2 will ultimately produce a master plan for the PUC system, and is scheduled for completion in 1999. Phase 3 is the implementation phase of the master plan, and will include an environmental review, design, and construction of the plan elements. Construction is anticipated as early as 2001.

☞Photo: San Francisco Water Temple

Without any improvements to its water supply reliability, SCVWD is forecasted to face the largest drought year shortages in the San Francisco Bay Region. The District released an integrated water resources plan in December 1996 to address water supply reliability through 2020. The primary components of the preferred strategy include water banking, water transfers, water recycling, and water conservation. Components are scheduled to be phased into operation as necessary to meet increasing demands. Implementation of specific components is designed to be flexible, with a list of contingency strategies to meet changing conditions. The plan is to be updated every three to five years.

SCVWD had also entered into a one-year contract with Semitropic WSD to transfer 45,000 af of SWP water to Semitropic for in-lieu groundwater recharge in 1996. A long-term contract for 350,000 af of transfer and storage is currently being finalized. One issue to be resolved is wheeling arrangements for the California Aqueduct.

EBMUD's board approved its water supply action plan in 1995 to meet the objectives of its 1993 Water Supply Management Program EIR. The action plan and the 1993 EIR address improving water supply reliability in the EBMUD service area. The action plan's recommendation was to construct a Folsom South Canal connection to EBMUD's Mokelumne Aqueduct, which will allow the district to make use of its contract with the USBR for up to 150 taf of American River water. The project would be designed to operate in accordance with the 1990 Alameda County Superior Court's Hodge Decision, which confirmed the District's right to divert its contract amount subject to the court's physical solution. The physical solution contains instream flow requirements for the Lower American River which must be met prior to diversion.

EBMUD and USBR released an EIR/EIS to choose a preferred alternative for conveying American River supply in November 1997. Four alignment alternatives were evaluated for the environmental document. One alternative incorporates a concept developed by Sacramento County, the City of Sacramento, and EBMUD to construct a joint diversion facility near the American River's confluence with the Sacramento River. The joint water supply project would divert water near the confluence to Sacramento's Fairbairn Water Treatment Plant. EBMUD would then convey treated water to the Folsom South Canal and a proposed canal extension, and ultimately, to the Mokelumne Aqueduct. Sacramento City and County would deliver their share of the diverted water to local water users.

In 1997, San Joaquin County interests proposed a groundwater storage project that would allow EBMUD to store surface water in San Joaquin County aquifers and would provide significant benefits to San Joaquin County water users. A JPA of San Joaquin County water agencies hopes to initiate a pilot project that would help assess the feasibility of this conjunctive use proposal. EBMUD has agreed to provide water for the project and is retaining this alternative for consideration as a means to provide more out-of-service area storage and improved supply reliability during droughts.

EBMUD has also been involved in negotiations related to instream flows in the Mokelumne River. In 1981, FERC issued a license to EBMUD for operation of hydropower facilities at Pardee and Camanche reservoirs, which incorporated an existing instream flow

agreement between the district and the DFG. During the 1987-1992 drought, poor fishery conditions on the Mokelumne and fish losses at the district's Camanche fish hatchery prompted FERC to investigate and evaluate fishery flows. FERC issued a Final EIS in November 1993, which was opposed by all the included parties. Subsequent negotiations led to preparation of a settlement agreement by EBMUD, DFG, and USFWS which was submitted to FERC for review in June 1997. The agreement's flows, which have already been implemented by EBMUD, will significantly impact the district's water supply. EBMUD estimates that the 2020 shortage during the design drought period with the new agreement flows would increase from 130 taf to 185 taf. The district will continue to pursue reliability enhancement options to meet the expected increased shortage.

Contra Costa Water District is facing a number of issues associated with its CVP supply, which is delivered via the Contra Costa Canal. The district is primarily dependent upon its supplies provided by its CVPcontract, which was amended in 1994 to include operation of Los Vaqueros Reservoir. (The District's Los Vaqueros Reservoir is an offstream storage facility designed to improve water supply quality and to provide emergency storage within the service area. It does not develop new water supply for the District.) CCWD's contract is scheduled to expire in 2010, but CVPIA established financial penalties for not renewing by 1997. The district will continue to weigh the potential loss of supply associated with renewal against the financial penalties. The agency anticipates that its current 195 taf contract may be reduced during contract renewal.

Bay Area Regional Water Recycling Program With passage of Title 16 of PL 102-575 in 1992, USBR joined with Bay Area water and wastewater agencies to fund a study of regional water recycling potential. The Bay Area Regional Water Recycling Program (formerly Central California Regional Water Recycling Program) was established in 1993 to develop a regional partnership to maximize Bay Area water recycling. The BARWRP is sponsored jointly by USBR, the Department, and 13 Bay Area water and wastewater agencies. During the first phase of the program, completed in April 1996, the participating agencies explored potential uses for water recycled from Bay Area wastewater treatment plants. The feasibility study showed that a

regional approach to water recycling to achieve water supply increases and environmental benefits would be productive.

A major component of the 1996 feasibility study was the assessment of potential recycled water use in the Central Valley and other locations outside the Bay Area. The regional water recycling master plan, currently underway, will focus on recycled water markets in the Bay Area. A limited assessment of agricultural uses immediately south of Santa Clara County will occur, but no further assessment of Central Valley uses will be included. Another major component of the feasibility study was the assessment of options to improve recycled water quality with respect to salinity. Two options originally assessed will not be considered in the master plan -- on-site agricultural salt management and management of agricultural drainage.

Water Management Options for the San Francisco Bay Region

Agencies throughout the Bay Area are in various stages of developing plans to improve the water service reliability of their service areas. Table 7-12 shows the comprehensive options list for the San Francisco Bay Region. The table reflects the results of the initial screening and indicates the reason for those options which are deferred. The retained options were evaluated and scored (see Table 7A-2 in Appendix 7A) based on criteria discussed in Chapter 6. The results of the options evaluation are shown in Table 7-13.

Table 7-12. Comprehensive List of Options

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to 0.8ETo	Retain	
	Residential Indoor Water Use	Defer	A low level of water use has already been achieved.
	Interior CII Water Use	Retain	
	Distribution System Losses	Retain	
Agricultural			
	Seasonal Application Efficiency Improvements	Defer	No substantial depletion reductions attainable.
	Flexible Water Delivery	Defer	No substantial depletion reductions attainable.
	Canal Lining and Piping	Defer	No substantial depletion reductions attainable.
	Tailwater Recovery	Defer	No substantial depletion reductions attainable.
Modify Existing Reservoirs/Operations			
	Enlarge Lake Hennessey / Napa River Diversion	Retain	
	Enlarge Bell Canyon Reservoir	Retain	
	Enlarge Bell Canyon Reservoir / Napa River Diversion	Retain	
	Enlarge Pardee Reservoir	Retain	
	Enlarge Camanche Reservoir	Retain	
	Enlarge Briones Reservoir	Defer	geologic hazards
	Enlarge Chabot Reservoir	Defer	substantially developed residential
	Enlarge Leroy Anderson Reservoir	Retain	
	Upgrade Milliken Treatment Plant	Retain	
	Reoperate Rector Reservoir	Retain	
New Reservoirs/Conveyance Facilities			
	Chiles Creek Reservoir Project / Napa River Diversion	Retain	
	Enlarge Lake Hennessey / Chiles Creek Project / Napa River Diversion	Retain	
	Carneros Creek Reservoir / Napa River Diversion	Retain	
	Upper Del Valle Reservoir	Retain	
	Buckhorn Dam and Reservoir	Retain	
	Upper Kaiser Reservoir	Retain	
	Upper Buckhorn Reservoir	Retain	
	Middle Bar Reservoir (Amador & Calaveras counties)	Retain	
	Duck Creek Offstream Reservoir	Retain	
	Devils Nose Project (Amador County)	Retain	
	Clay Station Reservoir (Sacramento County)	Defer	wetlands, endangered species
	Alamo Creek Reservoir	Defer	substantially developed residential
	Bolinger Reservoir	Defer	substantially developed residential

Table 7-12. Comprehensive List of Options (cont.)

Cull Canyon Dam	Defer	substantially developed residential
Canada del Cierbo Reservoir	Defer	Storage cost too high ($16,000/AF)
Curry Canyon Reservoir	Defer	substantially developed residential
Delta Island Storage (San Joaquin County)	Defer	Storage cost too high ($17,000/AF)
Lower Kaiser Reservoir	Defer	Storage cost too high ($9,000/AF)
Bailey Road Reservoir	Defer	Storage cost too high ($21,000/AF)
Folsom South Canal Connection Project	Retain	
Groundwater/Conjunctive Use		
Milliken Creek Conjunctive Use	Retain	
Lake Hennessey Conn Creek Conjunctive Use	Retain	
Recharge Dumbarton Quarry Pits	Defer	Unsuitable, fractured bedrock
Sunol Valley Groundwater Recharge	Defer	Limited aquifer production
ACWD Increased Local Recharge	Defer	Insignificant yield increase
Water Transfers/Banking/Exchange		
Napa / Solano County Water Agency Exchange	Defer	SCWA is not interested in exchange
Solano County Water Agency	Defer	No proposals identified at this time.
Contra Costa Water District	Defer	No proposals identified at this time.
Alameda County FC&WCD, Zone 7	Retain	
Santa Clara Valley Water District	Retain	
Water Recycling		
Group 1 (Cost < $500/AF)	Retain	
Group 2 (Cost $500/AF - $1,000/AF)	Retain	
Group 3 (Cost > $1,000/AF)	Retain	
Desalination		
Brackish Groundwater		
Alameda County Water District Aquifer Recovery Project	Retain	
Seawater		
Marin Municipal Water District Desalination Project	Retain	
Other Local Options		
New Surface Water Diversion from Sacramento River by cities of Benicia, Fairfield, & Vallejo	Retain	
Statewide Options		
CALFED Bay Delta Program	Retain	
SWP Interim South Delta Program	Retain	
SWP American Basin Conjunctive Use Program	Retain	
SWP Supplemental Water Purchase Program	Retain	
Drought Water Bank	Retain	
Enlarge Shasta Lake	Retain	

Conservation

Urban. The urban water supply forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed the BMPs are considered as options. All urban conservation options except reducing residential interior water use were retained. The latter option was deferred because interior water use has, on average, already attained the levels evaluated in the Bulletin for future water management options. Reducing outdoor water use to 0.8 ET_o in new development would attain about 20 taf per year of depletion reductions, while extending this measure to include existing development would reduce depletions by about 140 taf per year. Reducing commercial, institutional, and industrial water use by an additional 2 percent and 3 percent would attain 10 taf and 15 taf of depletion reductions per year, respectively. About 2 taf of depletion reductions would be attained by reduction distribution system losses to 7 percent.

Agricultural. Agricultural conservation options were deferred for this region. Due to the relatively small amount of irrigated acreage in the region and the high seasonal application efficiencies attained on average throughout the region, no significant depletion reductions would accrue.

Modify Existing Reservoirs/Operations

As shown in Table 7-12, Napa County Flood Control and Water Conservation District has considered a number of reservoir enlargement options which would provide additional offstream storage for Napa River flows. In the South Bay, Santa Clara is evaluating enlarging Leroy Anderson Reservoir, which would increase SCVWD's supply by about 25,000 af. EBMUD has several proposals to enlarge both of its Mokelumne River reservoirs. The improvement of system yields associated with these projects has not been determined.

Reoperating Rector Reservoir in Napa County would provide a small increase of approximately 1,200 af in system yield. Napa CFC&WCD is also considering a modification of its Milliken Water Treatment Plant, which would generate a small increase (450 af) in its water supply.

New Reservoirs and Conveyance Facilities

Ten new reservoirs were evaluated for Bay Area water agencies. Napa CFC&WCD investigated several diversion and storage projects, including Chiles Creek Reservoir Project and Carneros Creek Reservoir Project. The viability of these offstream storage projects depends upon the district's ability to make Napa River diversions. (SWRCB has declared the Napa River to be fully appropriated during parts of the year.) Some agencies, including ACWD, have examined an Upper Del Valle Reservoir Project. EBMUD has considered three new storage reservoirs in its service area and two new reservoirs in the Mokelumne basin (Middle Bar and Devil's Nose projects). These storage options have been inactive since EBMUD's focus on the Supplemental Water Supply Project.

As discussed in the Water Management Issues section, EBMUD and USBR released a DEIR/EIS in 1997 for EBMUD's diversion of its American River CVP supply. The district has estimated that the drought year yield of this project would be 16,900 af. (The DEIR/EIS evaluates alternatives for conveyance of the water. Project yield remains the same in either of the conveyance alternatives.)

☞Photo: Folsom South Canal from USBR

Groundwater/Conjunctive Use

Only two groundwater or conjunctive use options passed the initial evaluation. Napa CFC&WCD has two proposals to construct conjunctive use facilities adjacent to existing surface water facilities. The proposed Milliken Creek Conjunctive Use Project would allow the City of Napa and the Silverado Country Club to share surface and groundwater supplies, and would provide an additional drought yield of 1,900 af. The proposed Lake Hennessey/Conn Creek conjunctive use project would make the City of Napa's surface water available to agricultural users in exchange for rights to pump groundwater during droughts. This option would provide an estimated additional 5,000 af during drought years.

Water Transfers/Banking/Exchange

Agencies throughout the Bay Area are proposing to negotiate for new or additional water imports into the region. Most of these proposals are preliminary. Water transfer proposals by SCWA, CCWD, and, ACFC&WCD, Zone 7 all include transfers from some as-yet-unnamed

Sacramento Valley water users. The actual amount of water available through these proposals is unknown and the competition for transfers will certainly impact both price and availability. A likely transfer option for ACFC&WCD, Zone 7 is the permanent transfer of 7,000 af of SWP entitlement from Kern County Water Agency. Transfers of this type are provided for in the Monterey Agreement.

In addition to the long-term agreement with Semitropic for banking 350,000 af of water, SCVWD has entered into a three-way transfer agreement with the San Luis Delta Mendota Water Authority and USBR. Under this option, participating member agencies of SLDMWA can receive some of SCVWD's federal water allocation in normal and above-normal water years in exchange for committing to make available a share of their federal allocation during drought years. This option would provide SCVWD with up to 14,250 af in drought years and is discussed in more detail in Chapter 6.

Water Recycling

A recent water recycling survey indicated there are 29 water recycling options in the San Francisco Bay Region, with a total proposed 2020 yield of 92,000 af. The average price of recycled water from these options is just over $500 /af, with a range from $95 to $2,060 /af. The most common use for recycled water would be for landscape irrigation. A few options are proposed for either industrial use, agricultural use, or both.

One consideration in evaluating water recycling proposals is that a number of options may be proposed for the same wastewater treatment plant. These options depend upon different distribution systems and are therefore considered separately for this report. Some of the larger projects with their associated 2020 yield include the South Bay Water Recycling Program (21,000 af), the Central Contra Costa Sanitation District Industrial Use Project (20,000 af), the San Francisco Water Recycling Management Plan (11,000 af), and the San Ramon Valley Recycled Water Project (9,000 af). Most of the remaining water recycling options are in the range of 1,000 to 4,000 af.

Several South Bay wastewater and water agencies are participating in the Bay Area Regional Water Recycling Program, which would develop and maintain a regional water recycling distribution system. This regional approach would allow more extensive use of

recycled water throughout the South Bay, and perhaps provide an opportunity for sales or exchanges of water outside of the region. The local options discussed above, however, depend upon much of the same recycled water considered for use in the BARWRP option.

Desalination

Alameda County Water District has evaluated a brackish water desalting plant to indirectly increase overall water supply reliability by increasing use of groundwater resources. Water pumped from the district's aquifer recovery project wells would be desalinated and blended with groundwater and Hetch Hetchy water to provide a quality consistent with other sources of supply. The plant would produce 9 taf per year at a cost of about $500/ af.

In the past, Marin Municipal Water District examined seawater desalination as an option to augment its water supply. The district studied constructing a 10 mgd reverse osmosis desalination plant near the western end of the San Rafael Bridge. The plant's yield would be approximately 10 taf at a cost of $1,900/af.

Other Local Options

SCWA and its member agencies have been examining several surface water management projects to improve their water supply reliability. One proposal is to increase diversion through the SWP's North Bay Aqueduct by applying for additional water rights from the Delta. The cities of Benicia, Fairfield, and Vallejo have filed water right applications for a total of 31,000 af per year. (Vacaville, in the Sacramento River Hydrologic Region, would receive 8,500 af per year from this source).

Statewide Options

Active planning for statewide water supply options is being done currently for the CALFED Bay-Delta Program and for SWP future supply. See Chapter 6, Evaluating Options from a Statewide Perspective, for discussion on statewide water supply augmentation options. *[The following text on SWP and CALFED supplies is a placeholder for potential outcomes of CALFED process. Text will be changed as CALFED results become available.]*

CALFED Bay-Delta Program. Improving conditions in the Sacramento-San Joaquin River Delta would provide improvement to SWP supply reliability. For illustrative purposes,

assuming improved Delta conditions through the implementation of CALFED alternatives, additional SWP yield to the region could be 10,000 af in drought years.

State Water Project Improvements. The Department has three programs underway to improve SWP yields to its contractors. Each program is discussed in Chapter 6. The ISDP would augment SWP supplies to the San Francisco Bay Region 7,000 af in drought years. The American Basin Conjunctive Use Program would provide 18 taf to the region in drought years, and the Supplemental Water Purchase Program could provide an additional 12 taf in drought years.

Drought Water Bank. Based on past experience with the Drought Water Bank, it is estimated that about 250,000 af of water is available for allocation. Of this amount, past experience suggests that about 58,000 af would be made available to the San Francisco Bay Region.

Enlarged Shasta Lake. Enlarging Shasta Lake to 13 maf of storage would increase drought year yield by about 1.5 maf. If we assume one-third of this yield is allocated to the environment, and the remaining two-thirds is allocated among the State and federal projects, the region could potentially receive about 40 taf per year.

Table 7-13. San Francisco Bay Hydrologic Region Options Ranking

Option	Rank	Cost per af ($)	Potential Gain (taf) Avg	Potential Gain (taf) Drt
Conservation				
Urban				
Outdoor Water Use - New Development	M	750	20	20
Outdoor Water Use -New and Existing Development	L	*	140	140
Interior CII Water Use (2%)	M	500	10	10
Interior CII Water Use (3%)	L	750	15	15
Distribution System Losses (7%)	M	300	2	2
Modify Existing Reservoirs/Operations				
Enlarge Lake Hennessey / Napa River Diversion	M	500	12	-
Enlarge Bell Canyon Reservoir	M	*	*	2
Enlarge Bell Canyon Reservoir / Napa River Diversion	M	*	*	4
Enlarge Pardee Reservoir	M	*	*	30
Enlarge Camanche Reservoir	M	*	*	15
Enlarge Leroy Anderson Reservoir	M	4,400	*	25
Upgrade Milliken Treatment Plant	H	*	1	1
Reoperate Rector Reservoir	H	800	-	1
New Reservoirs/Conveyance Facilities				
Chiles Creek Reservoir Project / Napa River Diversion	M	960	12	-
Enlarge Lake Hennessey / Chiles Creek Project / Napa River Diversion	M	840	15	-
Carneros Creek Reservoir / Napa River Diversion	L	1,750	12	-
Upper Del Valle Reservoir	M	1,600	5	2
Buckhorn Dam and Reservoir	M	*	*	23
Upper Kaiser Reservoir	M	*	*	6
Upper Buckhorn Reservoir	L	*	*	3
Middle Bar Reservoir	M	*	*	15
Duck Creek Offstream Reservoir	M	*	*	15
Devils Nose Project	M	*	*	23
EBMUD American River Supply	M	850	*	17
Groundwater/Conjunctive Use				
Milliken Creek Conjunctive Use	H	120	-	2
Lake Hennessey / Conn Creek Conjunctive Use	H	250	-	5
Water Transfers/Banking/Exchange				
Alameda County FC&WCD, Zone 7	H	*	7	7

Table 7-13. Continued

SCVWD / Delta Mendota Authority	H	*	-	14
Water Recycling				
Group 1 (Cost < $500/AF)	H	500	24	24
Group 2 (Cost $500/AF - $1,000/AF)	M	1,000	63	63
Group 3 (Cost > $1,000/AF)	M	1,500	5	5
Desalination				
Brackish Groundwater				
Alameda County Water District Aquifer Recovery Project	M	500	9	9
Seawater				
Marin Municipal Water District Desalination Project	L	1,900	10	10
Other Local Options				
New Surface Water Diversion from Sacramento River by cities of Benicia, Fairfield, & Vallejo	M	*	**	**
Statewide Options				
CALFED Bay / Delta Program	M	*	***	10
SWP Interim South Delta Program	M	100	***	7
SWP American Basin Conjunctive Use Program	H	150	-	18
SWP Supplemental Water Purchase Program	L	175	-	12
Drought Water Bank	H	175	-	58
Enlarge Shasta Lake	M	*	38	42

* Data not available to quantify.

** The three cities have applied for 31 taf of supplemental water.

*** Because the region does not have average year shortages, the region's SWP supplies from these options have been reallocated to the South Coast Region.

Water Resources Management Plan for the San Francisco Bay Region

Water shortages in the region are forecasted to be 376 taf by 2020. These shortages are expected to occur only in drought years and are primarily due to increased urban demands. Options likely be implemented by 2020 to meet these forecasted shortages are shown in Table 7-14.

Table 7-14.Summary of Options Most Likely to be Implemented by 2020 San Francisco Bay Region

Option	Potential Gain (taf)	
	Avg	Drt
Shortage	**0**	**376**
Conservation	-	32
Modify Existing Reservoirs/Operations	-	34
New Reservoirs/Conveyance Facilities	-	17
Groundwater/Conjunctive Use	-	7
Water Transfers/Banking/Exchange	-	21
Recycling	-	92
Desalination	-	9
Statewide Options	-	**93**
Total Potential Gain	-	**305**
Remaining Shortage	**0**	**71**

Implementation of BMPs will continue through 2020 and is reflected in the base demand levels for urban water use. Urban conservation options most likely to be implemented, based on costs and feasibility, would provide 32 taf in water savings in the region.

Several Bay Area agencies will likely reduce shortages by about 40 taf by implementing conjunctive use projects and modifying existing facilities or operations. Identified conjunctive use and treatment plant upgrade options could provide 9 taf to Napa Valley communities. Raising Pardee Dam could add 150 - 200 taf of storage capacity which could provide 30 taf in drought years for EBMUD's service area.

Agencies throughout the region have ambitious plans for water recycling as a future water supply option. These options could provide an additional 92 taf to the region by 2020. EBMUD's

American River supply would augment drought year supplies by 17 taf. Water transfer agreements being negotiated with Central Valley agencies will likely add 21 taf in the near future. Statewide options including a Delta fix, SWP improvements, and drought water bank would likely augment supplies by 93 taf. Even with implementing the most likely options, a shortage of 71 taf in the region would remain. Additional options exist to meet more of the shortages, but are quite costly. The remaining shortages, mostly in the South Bay, could be met by drought contingency measures implemented by local water agencies.

Many South Bay water purveyors' systems are interconnected, reflecting a common reliance on the SWP, CVP, and Hetch Hetchy facilities for their water supplies. EBMUD has connections to CCWD and the city of Hayward, which also contracts with the SFPUC. CCWD and SCVWD are connected to the Delta via CVP facilities. SCVWD, ACWD, and ACFC&WCD, Zone 7 are connected by the SWP's South Bay Aqueduct. SFPUC now has a permanent connection to the SWP, to allow it to take delivery of water transfers wheeled by the SWP. These interconnections facilitate water transfers and are positive factors in water resources management in the South Bay.

Central Coast Hydrologic Region

Description of the Area

The Central Coast Region (Figure 7-4) is adjacent to the Pacific Ocean and extends from Santa Cruz County in the north to Santa Barbara County in the south. The region includes part of Santa Clara County, most of San Benito County, and all of Santa Cruz, Monterey, San Luis Obispo and Santa Barbara counties. The major topographic features include Monterey and Morro bays; the Pajaro, Salinas, Carmel, Santa Maria, Santa Ynez and Cuyama valleys; the Coast Range and the coastal plain of Santa Barbara County. The region is divided into two planning subareas: Northern (including all counties except San Luis Obispo and Santa Barbara) and the Southern (San Luis Obispo and Santa Barbara counties). During the summer months, temperatures are cool along the coastline and warmer inland. In the winter, temperatures remain cool along the coast but become cooler inland. Annual precipitation ranges from about 10 inches on valley floors at the south end of the region to as much as 50 inches on some of the highest peaks. The year-round frost-free climate of the coastal valleys makes them ideal for production of specialty crops such as strawberries and artichokes.

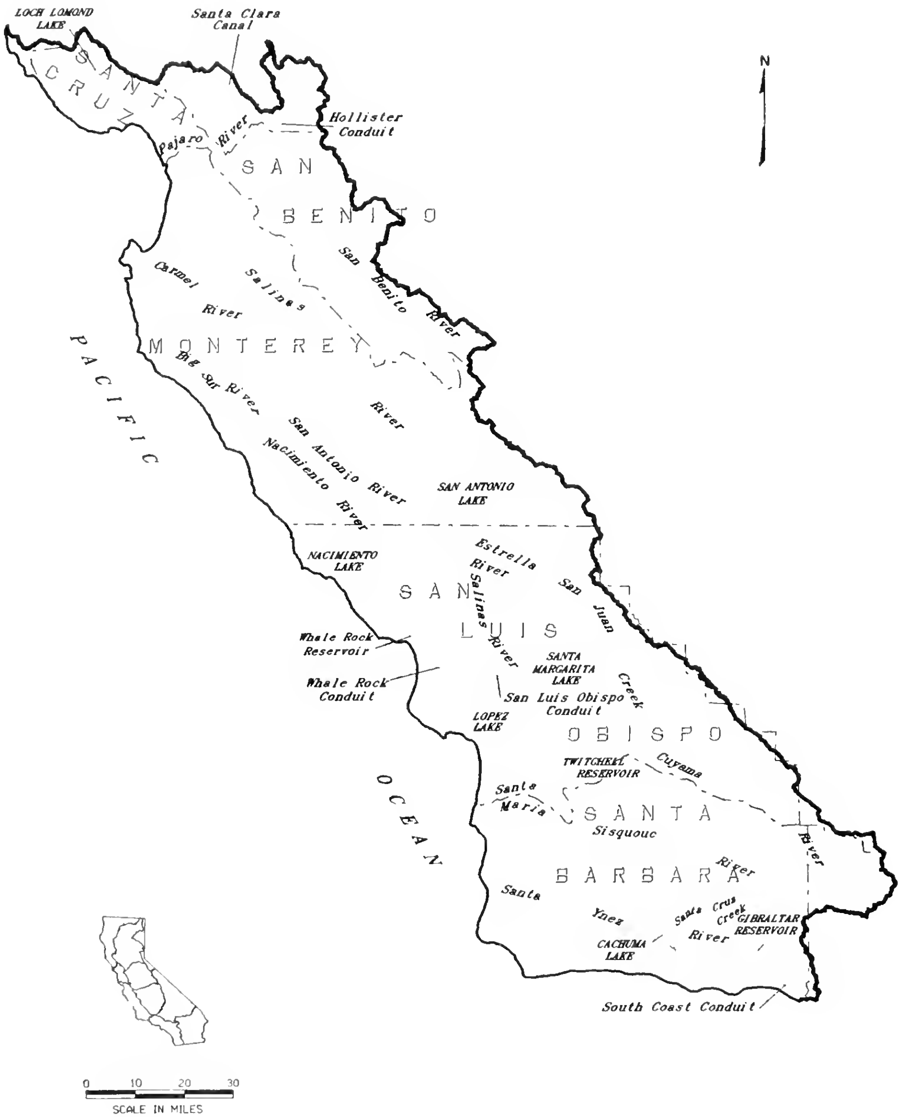
The principal population centers in the region are Santa Cruz, Hollister, Salinas, Monterey, Paso Robles, San Luis Obispo, Santa Maria, Goleta, and Santa Barbara. Intensive agriculture is found in the Salinas and Pajaro valleys in the north and the Santa Maria and lower Santa Ynez valleys in the south. Agricultural acreage has remained fairly stable during recent years, although urban development is encroaching on some valley agricultural lands. In the Pajaro and Salinas valleys, the major crops include vegetables, specialty crops, and cut flowers. Winegrape acreage has increased in the upper Salinas Valley. The flower seed industry in Lompoc Valley is thriving and attracts many tourists each year. Parts of the upper Salinas Valley and Carizo Plain are dry-farmed to produce grains. Table 7-15 shows the region's population and crop acreage for 1995 and 2020.

☞Photo: artichoke fields

Table 7-15. Population and Crop Acreage(in thousands)

	1995	**2020**
Population	1,346	1,946
Irrigated Crop Acres	572	570

Figure 7-4. Central Coast Hydrologic Region



Major industries include tourism; agricultural-related processing; and government and service sector employment. Oil production and transportation sites onshore and offshore are important to the economies of Santa Barbara and San Luis Obispo counties. San Luis Obispo County also has major thermal powerplants at Diablo Canyon and Morro Bay. Military facilities include Hunter-Leggett Military Reservation, Vandenberg Air Force Base, and Camp San Luis Obispo (Army Reserve).

Water Demands and Supplies

The water budget for the Central Coast Region is shown in Table 7-16. Groundwater is the primary source of water in the region, followed by local surface water. CVP water supply is delivered to the northern part of the region from San Luis Reservoir. SWP Coastal Branch deliveries to the southern part of the region are expected to begin in late 1997. Most of the water shortage in the region occurs as groundwater overdraft, although the overdraft is expected to lessen with SWP water deliveries and decreased agricultural demands.

Table 7- 16. Central Coast Region Water Demands and Supplies (taf/yr)

	1995		2020	
	Average	Drought	Average	Drought
Applied Water				
Urban	286	294	379	391
Agricultural	1,192	1,279	1,127	1,223
Environmental	108	27	108	27
Total Applied Water	1,585	1,600	1,614	1,642
Supplies				
Surface Water	308	150	367	183
Groundwater	1,045	1,142	1,029	1,145
Recycled and/or Desalted	18	26	42	42
Total Supplies	1,371	1,318	1,437	1,369
Shortages	214	282	177	273

Northern PSA

This planning subarea includes Santa Cruz, Pajaro Valley, the Monterey Peninsula, Salinas Valley, and Northern Monterey County. Water agencies include the Monterey County

Water Resources Agency, Monterey Peninsula Water Management District, Marina County Water District, California-American Water Company of Carmel, the Pajaro Valley Water Management Agency, the city of Santa Cruz, and San Benito County Water Conservation and Flood Control District.

The Northern PSA is comprised of a number of medium-to-small independent watersheds. There is limited infrastructure for water transfers among the watersheds and from outside of the region. The only water import from outside the region comes from CVP's San Felipe Unit, which imports 53,000 af per year into southern Santa Clara and San Benito counties.

Groundwater is the primary water source for the subarea. Groundwater recharge is provided by the Pajaro, Salinas, and Carmel rivers. San Clemente and Los Padres dams on the Carmel River (Monterey County), San Antonio Dam on the San Antonio River (Monterey County), and Nacimiento Dam on the Nacimiento River (in San Luis Obispo County) are the region's main surface water storage facilities. Water impounded in these reservoirs is managed to provide groundwater recharge.

Southern PSA

The largest water agencies in the southern PSA are two countywide agencies -- the San Luis Obispo County Flood Control and Water Conservation District and the Santa Barbara County Flood Control and Water Conservation District. The Central Coast Water Authority was formed in 1991 to construct, manage, and operate Santa Barbara County's 42 mile portion of the Coastal Aqueduct. There are additionally many small retail agencies and small municipalities which provide their own water supplies.

The major source of water in the two counties is from coastal groundwater basins. SLOCFCWCD and SBCFCWCD contract with the Department for SWP water, which began delivery to the area with the completion of SWP's Coastal Branch. San Luis Obispo County water agencies have requested 4,830 af per year of SWP water and Santa Barbara County water agencies have requested 42,486 af per year.

☞Photo: Coastal Branch Construction--pipe laying

Due to the 1987-1992 drought, two seawater desalination plants were constructed in the region. One plant, at Morro Bay, has an annual capacity of 670 af. The City of Santa Barbara's

plant has an annual capacity of 7,500 af. Although the Santa Barbara plant only operated briefly in 1992, it is considered in the water balance as an existing drought year supply under 1995 level of development.

Local Water Resources Management Issues

With limited surface supply and few surface water storage facilities, the growing demand for water is placing an increased dependence on groundwater resources in the Central Coast Region. As groundwater extractions exceed groundwater replenishment, the region's aquifers experience overdraft conditions. This condition has allowed seawater to advance into some coastal freshwater aquifers, causing long-term water quality degradation. Groundwater overdraft and the resulting seawater intrusion is a major concern in the region, especially in smaller coastal groundwater basins with limited storage capacities.

Salinas Valley In aquifers underlying the lower Salinas Valley, seawater intrusion was detected in wells about 8 miles from the coastline. In 1994, the SWRCB began investigating groundwater conditions in the Salinas Valley. SWRCB has suggested that adjudication may be necessary if the local agencies cannot halt seawater intrusion. The **Monterey County Water Resources Agency** has constructed a Castroville seawater intrusion project/Salinas Valley reclamation project in cooperation with the Monterey Regional Water Pollution Control Agency. Completed in 1997, the CSIP/SVRP will deliver about 20,000 af annually of tertiary treated water to agricultural users, thereby reducing groundwater pumping in areas most affected by seawater intrusion.

Salinas Valley Reclamation Project/Castroville Seawater Intrusion Project

Several decades of overpumping groundwater have caused seawater from the Monterey Bay to intrude into the aquifers that supply the Salinas Valley with nearly 100 percent of its fresh water. Seawater has intruded almost six miles inland to the 180-foot aquifer and two miles inland into the 400-foot deeper aquifer. This intrusion has rendered the groundwater too salty for either domestic or agricultural use. Replenishment of groundwater occurs primarily from percolation of surface water from the Salinas River and its tributaries. The construction of Nacimiento and San Antonio dams in 1957 and 1965, respectively, have helped keep groundwater levels relatively stable south of Gonzales, but because recharge from the river occurs so far south of this area and water moves very slowly through the ground, they have been of questionable benefit to the Castroville area. In 1994, the SWCRB began investigating the Salinas Valley. The SWRCB suggested that adjudication may be necessary if the local agencies could halt the seawater intrusion.

In late 1997, the MCWRA and the MRWPCA jointly completed the $78 million Salinas Valley Reclamation Project and the Castroville Seawater Intrusion Project . The SVRP is an upgrade of the existing regional secondary treatment plant in Marina into a 19,500 af/yr tertiary water reclamation plant. The CSIP distributes the reclaimed water, which accounts for approximately two-thirds of the area's irrigation needs, to 12,000 acres of Castroville area farms. During the low irrigation demand periods in winter, early spring and late fall, reclaimed water will supply most of the water needed for irrigation. During late spring, summer, and early fall, growers will receive a blend of reclaimed water and groundwater. This project will reduce groundwater pumping in the project area, thus reducing seawater intrusion. A two-year phase out following completion of the project will reduce the number of wells from 300 to 22. Additionally, the project will reduce the amount of secondary-treated wastewater to the Monterey Bay National Marine Sanctuary. The sanctuary is a federally-protected aquatic ecosystem extending from Point Reyes to San Luis Obispo with abundant marine resources including kelp forests, marine mammals, sea and shore birds and numerous fishes.

The MCWRA is also preparing a basin management plan for the Salinas Valley. Major components of the plan will likely include recommendations for dam modifications and reservoir reoperation, new conveyance systems, groundwater recharge, water recycling, conservation, weather modification (cloud seeding), regulatory tools (such as groundwater extraction ordinances), and drought contingencies. The basin management plan also will address nitrate management problems. Flood control is also a significant issue, as seen along the Salinas and Pajaro rivers during the 1995 floods.

Pajaro Valley Groundwater overdraft and seawater intrusion are also problems facing the Pajaro Valley. A basin management plan was approved in December 1993 by the PVWMA. Major components of the plan include new reservoirs and conveyance facilities, groundwater recharge; water imports; and conservation. Failing to implement the plan could result in intervention by the SWRCB, resulting in basin adjudication and restrictions on extractions.

Monterey Peninsula Between urban growth and the growth of the tourism industry, the Monterey Peninsula is expected to experience more frequent shortages in dry years. Water supply for the area comes from the Carmel River, which has relatively little developed storage. In its Monterey Peninsula water supply project final EIR/EIS, MPWMD chose the 24,000 af New Los Padres Reservoir on the Carmel River as its preferred alternative for meeting future water needs. The proposed reservoir would expand the Peninsula's water supply and protect and restore natural resources on the Carmel River. However, voters defeated bonds for the project in a 1995 election. MPWMD staff prepared an plan for water supply alternatives in 1996 which included recommendations for expanded groundwater production, additional recycled water use, desalination, and additional conservation programs.

☞Photo: sea otter

In 1995, SWRCB determined that Cal-Am was diverting approximately 10,700 af from the Carmel River without valid water rights. As a result, the SWRCB ordered that diversions from the Carmel River be reduced, and that sources outside of the basin be used. One of these sources could be additional groundwater production from the Seaside basin, but the use of this basin as a replacement for diversions from the Carmel River is being challenged in litigation. SWRCB indicated that the New Los Padres Reservoir should be reconsidered to restore Carmel River habitat values and provide for Cal-Am's water supply. In 1996, Cal-Am decided to proceed with the New Los Padres Reservoir, but with a reduced urban yield of 10,700 af to support only its existing water needs, without providing supplies for future growth.

Water management concerns in the Northern Monterey County include declining groundwater levels because of overdraft (estimated at about 11,700 af annually), seawater intrusion, and nitrate contamination. The area overlies parts of the Salinas and Pajaro groundwater basins and includes the area between the adopted boundaries of these two basins. (Within

Monterey County, groundwater management activities and authority are divided between the Pajaro Valley Water Management Agency and the Monterey County Water Management Agency.) Agricultural water demand is about 85 percent of total water demand. Residential development is scattered, and most residences are on wells and septic systems. There are no existing regional water delivery or sewer systems. Because of water supply problems, some restrictions on lot subdividing or adding second dwelling units have been instituted. An interim water management plan for the north county area has been prepared.

Santa Cruz County relies mostly on surface water diversions. Dry years pose a threat of water rationing and shortages because of the lack of adequate storage facilities. Seawater intrusion is a concern for groundwater users. For example, after years of stable conditions groundwater quality in municipal wells in the Soquel-Aptos area began to degrade in 1993-94 (Soquel Creek water, the largest purveyor in this part of the county, relies primarily on groundwater). As measured by chloride concentrations in monitoring wells along the Monterey Bay coastline, groundwater quality degraded noticeably in less than 4 years with salinity concentrations increasing from 20 to 40 mg/l to about 250 mg/l to 2,500 mg/l. These conditions occurred despite the District's managing its extractions to maintain coastal groundwater levels above sea level and decreasing its pumping.

Santa Clara Valley Water District and various retail agencies supply water throughout **Santa Clara County**. No additional water management programs are proposed for areas of the county in the Central Coast Region. Since most of Santa Clara County is in the San Francisco Bay Region, options for the county are discussed in that region.

The **City of San Luis Obispo** has been pursuing a Salinas Reservoir expansion project to supplement its water supply. The existing reservoir is owned by the USACE and is managed by the SLOCF&WCD. The expansion project involves installing spillway gates to expand the storage capacity of the existing reservoir from about 24 taf to 42 taf. The proposed project would increase the city's annual water supply by about 1,650 af, but would only supply a portion of the city's expected future water demands. An initial draft EIR was issued in late 1993. A revised draft EIR was issued in May 1997.

Current municipal **seawater desalting capacity** in the Central Coast Region is about 8,500 af, almost all of which is in the city of Santa Barbara's desalting plant. The remainder of the plants are small, less than 750 af in capacity. During the 1987-1992 drought, a number of seawater desalting projects were anticipated, but the return of average water years has put most of these plants on hold. Only Santa Barbara, Morro Bay, and the San Simeon Beach State Park installed plants because of the drought. A bond issue referendum on a 3 million-gallon-per-day seawater desalting plant for Monterey Peninsula Water Management District was rejected by voters in 1992. The plants in Santa Barbara and San Simeon are on standby. The plant at Morro Bay is used only during dry periods when groundwater supplies are limited.

In 1996, due to seawater intrusion in its groundwater basin, the Marina Coast Water District completed a 300,000 gallon per day (330 af per year) seawater desalting plant. The plant produces about 14 percent of the district's water supply.

☞Aerial photo: Cuyama Valley

Water Management Options for the Central Coast Region

Table 7-17 shows a comprehensive list of the options and whether an option was retained or deferred from further evaluation. The retained options were evaluated and scored (see Table 7A-3 in Appendix 7A) based on the criteria discussed in Chapter 6. The results of the options evaluation are shown in Table 7-18.

Table 7-17. Comprehensive List of Options Central Coast Region

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to 0.8ETo	Retain	
	Residential Indoor Water Use	Defer	A low level of water use has already been achieved.
	Interior CII Water Use	Retain	
	Distribution System Losses	Defer	No substantial depletion reductions attainable.
Agricultural			
	Seasonal Application Efficiency Improvements	Defer	No substantial depletion reductions attainable.
	Flexible Water Delivery	Defer	No substantial depletion reductions attainable.
	Canal Lining and Piping	Defer	No substantial depletion reductions attainable.
	Tailwater Recovery	Defer	No substantial depletion reductions attainable.
Modify Existing Reservoirs/Operations			
	Modify Nacimiento Spillway	Retain	
	Inter-Lake Tunnel - Nacimiento/San Antonio Reservoirs	Retain	
	Enlargement of Salinas Reservoir	Retain	
	Enlargement of Cachuma Reservoir	Retain	
	Enlargement of Lopez Reservoir	Defer	Too many acres of land inundated.
New Reservoirs/Conveyance Facilities			
	College Lake	Retain	
	Bolsa De San Cayetano Reservoir	Retain	
	Corncob Canyon Reservoir	Retain	
	Pescadero Reservoir	Retain	
	Gabilan Creek Dam	Retain	
	Feeder Streams (Various Sites)	Retain	
	Chalone Canyon Dam	Retain	
	Vaqueros Canyon Dam	Retain	
	New Los Padres Reservoir	Retain	
	Nacimiento Pipeline	Retain	
	Arroyo Seco Dam	Defer	Impacts to environment, residences, small resort.
	Barloy Dam	Defer	Questionable water supply.
	Mathews Dam	Defer	Questionable water supply.
	Jerret Dam	Defer	Questionable water supply.
	New San Clemente Reservoir	Defer	Strong regulatory agency objections.
	San Clemente Creek Reservoir	Defer	High probability of inundating spotted owl habitat.
	Cachuga Reservoir	Defer	Questionable supply and located outside MPWMD boundaries.
	Canada Reservoir	Defer	Questionable characteristics of rocks at dam site.

Table 7-17. Continued

Klondike Dam	Defer	Located near active faults; inundation of expensive residences.
Chupines Creek Reservoir	Defer	Questionable supply and located outside MPWMD boundaries.
Pine Creek	Defer	Potential impacts to environmentally sensitive areas.
Buckeye Creek	Defer	Located near active faults; unsuitable dam foundation.
Transfer from Lower Salinas Basin	Defer	Water rights problems.
Transfer from Little and Big Sur Rivers	Defer	Both rivers protected by State.
Lower Jack	Defer	Environmentally infeasible; riparian oak grassland.
Santa Rita	Defer	Environmentally infeasible; riparian oak grassland.
Camuesa and Salsipuedes Reservoirs	Defer	Environmental impacts; presence of endangered species.
Hot Springs, New Gilbraltar, and Round Corral Reservoirs	Defer	Insufficient yield, high unit cost of water.
Groundwater/Conjunctive Use		
College Lake Injection/Extraction Wells	Retain	
Increase Groundwater Development in Seaside Basin	Retain	
Seaside Conjunctive Use	Defer	Insufficient yield.
Salinas River Well System	Defer	Will not produce supply without implementing other new supply component.
Storage and Infiltration Basins/Recharge	Defer	Questionable water supply.
Upper/Lower Carmel Valley Well Development	Defer	Questionable water supply.
Water Transfers/Banking/Exchange		
CVP (San Felipe Project Extension)	Retain	
SWP (Coastal Branch/Salinas River/Nacimiento transfer)	Defer	Significant institutional issues.
Water Recycling		
Scotts Valley WD	Retain	
Watsonville Reclamation	Retain	
Santa Cruz Reclamation	Retain	
Aquifer Storage and Recovery Project	Retain	
Water Recycling - Golf Courses Cemeteries/Open Space	Retain	
Injected Treated Water/Carmel River Mouth	Defer	Health concerns.
City of San Luis Obispo	Retain	
Morro Bay	Retain	
Chorro Basin	Retain	
Santa Barbara Regional Reuse	Retain	
Desalination		

Table 7-17. Continued

Brackish Groundwater		
City of Santa Cruz	Retain	
Seawater		
Monterey Peninsula Water Management District	Retain	
Other Local Options		
Weather modification	Defer	Difficult to quantify.
Statewide Options		
CALFED Bay Delta Program	Retain	
SWP Interim South Delta Program	Retain	
SWP Supplemental Water Purchase Program	Retain	
Enlarge Shasta Lake	Retain	

Table 7-18. Ranking of Options Central Coast Region

Option	Rank	Cost per af ($)	Potential Gain (taf)	
			Avg	Drt
Conservation				
Urban				
Outdoor Water Use - New Development	M	750	10	10
Outdoor Water Use -New and Existing Development	L	*	30	30
Interior CII Water Use (3%)	L	750	2	2
Modify Existing Reservoirs/Operations				
Modify Nacimiento Spillway	H	80	20	-
Inter-Lake Tunnel - Nacimiento/San Antonio Reservoirs	H	170	20	-
Enlargement of Salinas Reservoir	M	300	2	2
Enlargement of Cachuma Reservoir	M	1,200	17	17
New Reservoirs/Conveyance Facilities				
College Lake	M	320	3	-
Bolsa De San Cayetano Reservoir	L	640	4	
Corncob Canyon Reservoir	L	590	10	-
Pescadero Reservoir	M	450	10	-
Gabilan Creek Dam	L	1,570	*	*
Feeder Streams (Various Sites)	M	400	*	*
Chalone Canyon Dam	M	460	*	*
Vaqueros Canyon Dam	L	1,020	*	*
New Los Padres Reservoir (24 taf)	M	400	24	24
New Los Padres Reservoir (11 taf)	M	770	11	11
Nacimiento Pipeline	M	950	16	16
Groundwater/Conjunctive Use				
College Lake Injection/Extraction Wells	M	100	2	2
Increase Groundwater Development in Seaside Basin	L	370	1	1
Water Transfers/Banking/Exchange				
CVP (San Felipe Project Extension)	M	540	13	2
Water Recycling				
Group 1 (Cost < $500/AF)	H	500	25	25
Group 2 (Cost $500/AF - $1,000/AF)	M	1,000	8	8
Group 3 (Cost > $1,000/AF)	M	1,500	5	5

Table 7-18. Continued

Desalination				
Brackish Groundwater				
City of Santa Cruz	M	1,100	5	5
Seawater				
Monterey Peninsula Water Management District	L	1,700	3	3
Statewide Options				
CALFED Bay / Delta Program	M	*	2	3
SWP Interim South Delta Program	M	100	1	1
SWP Supplemental Water Purchase Program	L	175	--	4
Enlarge Shasta Lake	M	*	8	13

* Data not available.

Water Conservation

Urban. The urban water supply forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. All urban conservation options except reducing residential interior water use were retained. Reducing outdoor water use to 0.8 ET_0 in new development would attain about 10 taf per year of depletion reductions, while extending this measure to include existing development would reduce depletions by about 30 taf per year. The remaining options were deferred or would only achieve minimal depletion reductions. Interior water use in the region is, on average, already at the levels evaluated as options in this Bulletin. Reducing CII water use by an additional 3 percent would attain 2 taf of depletion reductions per year. There is less than 1 taf of depletion reductions attainable with reduction in distribution system losses.

Agricultural. Agricultural conservation options were deferred for this region, because no depletion reductions would be achieved. Excess applied irrigation water recharges overdrafted aquifers in the major agricultural areas.

Modify Existing Reservoirs or Operations

In the Northern PSA, most of these options involve Nacimiento and San Antonio reservoirs. The options include raising and widening the spillway at Nacimiento Reservoir;

constructing a tunnel or pipeline between the two reservoirs, changing reservoir operation rules; or any combination of these reservoir modification options would likely be combined with other options (such as improved conveyance facilities or groundwater recharge projects). Some of these options are estimated to cost less than $100 /af -- raising and widening the spillway at Nacimiento Reservoir is one such option. Sediment removal may provide a very small amount of additional supply, and MPWMD is studying the effectiveness of sediment removal from its existing reservoirs (Los Padres and San Clemente).

There are two proposals for reservoir enlargements in the Southern PSA. The Salinas Reservoir enlargement project would install a radial gate to raise the spillway height 19 feet above the existing elevation, increasing the reservoir's storage capacity by 17,950 af, and the city of San Luis Obispo's annual yield by 1,650 af. In Santa Barbara County a proposed project would raise USBR's Bradbury Dam (Cachuma Reservoir) 50 feet for additional water supply plus an additional 40 feet for flood surcharge storage. The reservoir would serve the South Coast and the Santa Ynez Valley. This project could result in an additional annual yield of 17,000 af at a cost of about $1,200 per af.

New Reservoirs/Conveyance Facilities

Local water agencies have studied several new reservoir/conveyance facilities at different sites. In the Pajaro Valley, constructing a 27-foot high dam at the existing College Lake drainage pump house would create a 10,000 af reservoir at College Lake. The reservoir could be supplied with natural runoff and a supplemental 25 cfs diversion from Corralitos Creek during the winter. Its annual yield of 3,400 af could be supplied to the coastal or inland distribution systems through a 5-mile, 30-inch diameter pipeline. The cost of this option is estimated to be under $400/af. Other reservoir options include Corncob Canyon and Pescadero Creek, both of which could store up to 10,000 af; both of these options are estimated to cost less than $600 per acre-foot. Bolsa De San Cayetano (estimated to cost $640 per acre-foot) could store up to 4,000 af.

In the Salinas Valley, reservoir options include two offstream storage facilities in the Chalone Canyon and in Vaqueros Canyon, and an onstream reservoir on Gabilan Creek. A dam on Arroyo Seco was removed from further consideration as a water supply project, although

MCWRA may evaluate it as a flood control project. The Monterey Peninsula could receive about 24,000 af from the proposed New Los Padres Reservoir, at a cost of about $400/af. Located on the Carmel River, this new reservoir would inundate the existing Los Padres Dam. Although bonds to fund this option were narrowly rejected in a 1995 election, Cal-Am announced its intentions to proceed with the project, but at a reduced yield of 10,700 af. The southern parts of the North County could be served by supplies developed in the Salinas River basin. However, the cost of a distribution system for this water could be prohibitive.

SLOCFC&WCD has an annual 17,500 af entitlement from Nacimiento Reservoir, only about 1,300 af of which is now used. A pipeline would be needed for distributing the remaining 16,200 af. The preferred pipeline route would go through the communities of Paso Robles, Templeton, Atascadero, Santa Margarita, and San Luis Obispo and terminate near Avila Beach. It would serve 18 purveyors. This option is not affected by reservoir modifications under consideration by MCWRA.

Santa Barbara County has run into difficulties providing additional water supply because of the long-term environmental impacts from a single damsite or the presence of endangered species, as in the case of Camuesa and Salsipuedes reservoirs. In other cases, such as Hot Springs, New Gibraltar, and Round Corral reservoirs, insufficient yield or the high unit cost of water were sufficient to eliminate these projects as an option. These reservoir alternatives were evaluated in the 1985 DWR/Santa Barbara County report, *Santa Barbara County SWP Alternatives.*

There are opportunities to import water from these projects from the CVP or SWP into the Northern PSA. In the Pajaro Valley, an option involves extending a pipeline from the USBR's San Felipe Unit, which delivers water from San Luis Reservoir into Santa Clara and San Benito counties. PVWMA does not have a CVP water service contract. CVPIA banned execution of new water service contracts for an indefinite period of time. PVWMA could connect to the San Felipe Unit by constructing a 22-mile pipeline from the Watsonville Turnout. This 42-inch diameter pipeline, with a capacity of 75 cfs, would be able to deliver a maximum of 20,000 af per year. The agency expects the average annual yield of the project to be 13,000 af, if

a source of transferred water could be found. Northern Monterey County could also benefit from a San Felipe extension because of the close proximity to the Pajaro Valley

Groundwater/Conjunctive Use

Because groundwater is the primary water source for the Central Coast Region, many options have a groundwater recharge component either by itself, or in conjunction with surface water development projects. In the Northern PSA, the Salinas Valley well system would include 16 wells along the Salinas River between Greenfield and Chualar. Water pumped from these wells would induce additional groundwater recharge. This option could only be implemented in combination with other options, such as modifying and reoperating existing reservoirs, a diversion structure and off-stream storage facility along the Salinas River, or related conveyance facilities, and is thus deferred as a stand-alone option. In the Pajaro Valley, options include the Pajaro recharge canal (1,500 af annually) and the College Lake injection/extraction wells (seven wells to inject diverted surface runoff, which is currently captured in College Lake). These wells would be used to extract groundwater during dry years when deliveries of San Felipe water are reduced. In the Monterey Peninsula, the Seaside groundwater basin has the potential to produce an additional 1,000 af; this option may be pursued because of SWRCB's order which encourages the maximum use of supplies from Seaside to reduce diversions from the Carmel River. Another option would be to retrofit existing wells in the Seaside Basin with injection/extraction equipment to increase storage and use of Carmel River and other supplies more efficiently. This option would include a series of new wells and pipeline system from inland areas (Fort Ord) to the Monterey Peninsula. The system would be operated primarily for drought year supply. Yields and costs of this option are unknown at present.

In Santa Cruz County, options include several new wells and deep brackish groundwater wells (with reverse osmosis treatment facilities) in the northern coast area. The new wells would provide an additional water supply of about 3,000 af while the brackish wells would be used for drought contingency. The groundwater resources of the north county could be increased by developing small local recharge projects, such as retention basins. However, the incremental yield of these projects would be small since the soils in the area are sandy and runoff is minimal. There are no physical facilities available for artificial recharge in the Southern PSA, but there are

some potential sites along coastal streams in San Luis Obispo County where additional runoff could be used for recharging groundwater basins.

Water Transfers/Exchange

In the Salinas Valley, the best opportunity for imported supplies involves purchasing SWP water from the Coastal Branch which could either (1) be traded with San Luis Obispo County for that county's existing entitlement to Nacimiento reservoir water, or (2) be delivered directly through a pipeline constructed from the aqueduct's crossing at the Salinas River. This option is deferred in this Bulletin because of its significant institutional issues.

Water Recycling

For the Northern PSA, options under consideration would treat wastewater to tertiary levels, then deliver it for direct agricultural irrigation in the Castroville area (similar to the Castroville seawater intrusion project) or for groundwater recharge. In the Salinas Valley, an aquifer storage and recovery program would use injection wells to store recycled water produced during the winter, then extract this water for irrigation in the Castroville area during the summer months. This program has an estimated annual yield of up to 10,000 af.

In the Pajaro Valley, a 12-or 18-mgd reclamation plant would be constructed adjacent to the existing Watsonville Wastewater Treatment Plant. The 12 mgd plant (about 13,400 af annually) would only treat water from the Watsonville area, whereas the 18 mgd plant (about 20,100 af annually) would treat water from both Watsonville and Santa Cruz. The 18 mgd option would require constructing a pipeline from Santa Cruz to Watsonville to transport treatment plant effluent.

In the Monterey Peninsula, the Carmel Area Wastewater District/Pebble Beach Community Services District treatment plant could be expanded to provide more recycled water (up to 100 af annually) which could be used on golf courses, open space, or cemeteries. In 1992, local water agencies studied potential markets for recycled water produced by the regional reclamation plant near Marina. Potential uses of reclaimed water in Fort Ord, Seaside, and other Monterey Peninsula communities with a potential annual demand of up to 1,000 af were identified, but the uses were deemed economically infeasible at that time. This study is currently being updated to reflect the closure of Fort Ord.

For the Southern PSA, recycled water projects have been proposed in conjunction with construction of new or expanded municipal wastewater treatment plants. In coastal areas—such as San Luis Bay, Estero, and south San Luis Obispo County— treated wastewater is discharged to the ocean, and reusing the wastewater would help reduce water supply shortages. (In the city of San Luis Obispo and in communities along the Salinas River, the wastewater recharges to the groundwater basin.)

Planned reuse projects in Santa Barbara County include the Santa Barbara regional water reuse project, which would provide 1,555 af of reclaimed water annually for landscape irrigation within the city of Santa Barbara, Montecito Water District, and Summerland County Water District. This project would replace potable water being used for irrigation. Another project could be expanding Lompoc's secondary treatment facilities and Santa Barbara's tertiary treatment facilities for an additional annual yield of 2,000 af by the year 2000.

Desalination

Several coastal cities in the region have identified desalination as options for additional water supply. The city of Santa Cruz is conducting a feasibility study on a 4,500 af per year brackish groundwater desalting plant to supplement local water supplies. The Cambria and San Simeon community services districts had plans to jointly construct a sea water desalting plant with 320 af per year capacity initially, ultimate capacity of 1,300 af annually. This project has recently been put on hold. Monterey Peninsula Water Management District had plans for a 3,400 af per year sea water desalting plant which was defeated by voters in the 1992 election.

☞Photo: Marina CWD's new desalter

Other Local Options

In the Northern PSA, MCWRA has a weather modification program which targets the watersheds of the Nacimiento and San Antonio rivers and the Arroyo Seco. As a result, MCWRA estimates that increased annual flows into reservoirs ranged from about 8,000 af to 68,000 af between 1990 to 1994. San Luis Obispo had a 3-year cloud seeding program that began in January 1991 to produce more runoff in the Salinas and Lopez watersheds. Although this program has ended, future programs may be a possibility. Future weather modification options are difficult to quantify and are deferred from further evaluation in this Bulletin.

Statewide Options

Active planning for statewide water supply options is being done currently for the CALFED Bay-Delta Program and for SWP future supply. See Chapter 6 for discussion on statewide water supply augmentation options. *[The following text on SWP and CALFED supplies is a placeholder for potential outcomes of CALFED process. Text will be changed as CALFED results become available.]*

CALFED Bay-Delta Program. Improving conditions in the Sacramento-San Joaquin River Delta would provide improvement to SWP supply reliability. For illustrative purposes, assuming improved Delta conditions through the implementation of CALFED alternatives, additional SWP yield to the region could be 2,000 and 3,000 af in average and drought years, respectively.

State Water Project Improvements. The Department has two programs underway which would improve SWP yields to its contractors in the Central Coast Region. Each program is discussed in Chapter 6. The ISDP would augment SWP supplies to the region by 1,000 af in average and drought years. The Supplemental Water Purchase Program could provide an additional 4 taf in drought years.

Enlarged Shasta Lake. Enlarging Shasta Lake to 13 maf of storage would increase drought year yield by about 1.5 maf. If we assume one-third of this yield is allocated to the environment, and the remaining two-thirds is allocated among the State and federal projects, the region could potentially receive 8 taf and 13 taf in average and drought years, respectively.

Water Resources Management Plan for Central Coast Region

By 2020, shortages in the region are projected to be about 177 taf for average year conditions and 273 taf for drought year conditions. Table 7-19 shows the options most likely to be implemented to meet these shortages. As discussed earlier, local water agencies in the Central Coast have done extensive water management planning. In most cases, the recommendations contained in the local agencies' basin management plans or other planning documents were reviewed and incorporated into the option evaluation process.

A mix of options can help alleviate projected water shortages in the Central Coast Region. Local options include urban water conservation, modifying existing reservoirs, new

reservoirs and conveyance, groundwater conjunctive use, water transfers, water recycling and desalination. To a lesser extent, statewide options could add 3 to 4 taf in average and drought years respectively. Even with these options, however, some remaining shortages are projected to occur in 2020, mostly in the Southern PSA.

The urban water conservation options beyond BMPs that would likely be implemented would add 10 taf in depletion reductions in the region. Additional reliance on water recycling will be likely in the future to alleviate shortages. There could be 40 taf of additional water recycling in the region, producing 38 taf of new water supply. This amount is in addition to the 2020 base level of 42 taf of new water supply from water recycling. Recycled water would be used for landscaping, direct agricultural application, and groundwater recharge.

In the Pajaro Valley, options that would most likely be implemented by 2020 would include a pipeline to connect to the CVP's San Felipe Unit to provide an opportunity for water transfers.

Modifying existing reservoirs or constructing new reservoirs are likely options for the region. One likely option to augment water supplies in the Salinas Valley would be to raise and widen Nacimiento Spillway. Raising the spillway 6.5 feet would increase storage capacity by 34,000 af, increasing the reservoirs yield by about 20,000 af. A long-term water management plan for the Monterey Peninsula would likely include construction of the proposed New Los Padres Dam, which could augment supplies by 24 taf if the larger reservoir was built.

In San Luis Obispo County, current planning focuses upon the Nacimiento pipeline, which would convey a portion of the county's entitlement of 17,500 acre-feet per year from Lake Nacimiento in northern San Luis Obispo County. Communities potentially receiving supplies from this option include the City of San Luis Obispo and Cayucos (through an exchange of water from Nacimiento and Whale Rock Reservoirs). In addition, the communities of Paso Robles, Templeton, and Atascadero may also receive supplies for groundwater recharge. Other sources of supply for San Luis Obispo County include enlarging Salinas Reservoir to increasing the City of San Luis Obispo's water supply by about 1,650 acre-feet per year.

Statewide options would add only 3 to 4 taf to the region. However, the completion of SWP's Coastal Branch makes water transfers and exchanges an option in the future.

If implemented, the identified options would still leave remaining shortages in average and drought years of 34 taf and 170 taf, respectively.

Table 7-19. Options Most Likely to be Implemented by 2020 Central Coast Region

Option	Potential Gain (taf)	
	Avg	Drt
Shortage	**177**	**273**
Conservation	10	10
Modify Existing Reservoirs/Operations	22	2
New Reservoirs/Conveyance Facilities	50	40
Groundwater/Conjunctive Use	2	2
Water Transfers/Banking/Exchange	13	2
Recycling	38	38
Desalination	5	5
Statewide Options	3	4
Total Potential Gain	**143**	**103**
Remaining Shortage	**34**	**170**

South Coast Hydrologic Region

Description of the Area

The South Coast is the most urbanized California's region (Figure 7-5). Although it covers only about 7 percent of the State's total land area, it is home to roughly 54 percent of the State's population. Extending eastward from the Pacific Ocean, the region is bounded by the Santa Barbara-Ventura county line and the San Gabriel and San Bernardino mountains on the north, and a combination of the San Jacinto Mountains and low-elevation mountain ranges in central San Diego County on the east, and the Mexican border on the south. Topographically, the region is comprised of a series of broad coastal plains, gently sloping interior valleys, and mountain ranges of moderate elevations. The largest mountain ranges in the region are the San Gabriel, San Bernardino, San Jacinto, Santa Rosa, and Laguna mountains. Peak elevations are generally between 5,000 and 8,000 feet above sea level; however, some peaks are nearly 11,000 feet high.

The climate of the region is Mediterranean-like, with warm dry summers followed by mild winters. In the warmer interior, maximum temperatures during the summer can be over 90°F. The moderating influence of the ocean results in lower temperatures along the coast. During winter, temperatures rarely descend to freezing except in the mountains and some interior valley locations.

About 80 percent of the precipitation occurs during the four-month period from December through March. Average annual rainfall quantities can range from 10 to 15 inches on the coastal plains and 20 to 45 inches in the mountains. Precipitation in the highest mountains commonly occurs as snow. In most years, snowfall quantities are sufficient to support winter sports in the San Bernardino and San Gabriel mountains.

There are several prominent rivers in the region, including the Santa Clara, Los Angeles, San Gabriel, Santa Ana, Santa Margarita, and San Luis Rey. Some segments of these rivers have been intensely modified for flood control. Natural runoff of the region's streams and rivers averages around 1,200,000 af annually.

Figure 7-5. South Coast Hydrologic Region

The largest cities in the region are Los Angeles, San Diego, Long Beach, Santa Ana, and Anaheim. Despite being so urbanized, about one-third of the region's land is publicly owned. About 2.3 million acres is public land, of which 75 percent is national forest. Irrigated crop acreage accounts for a small percent of land use. Table 7-20 shows the region's population and crop acreage for 1995 and 2020.

Table 7- 20. Population and Crop Acreage (in thousands)

	1995	*2020*
Population	17,299	24,327
Irrigated Crop Acres	313	190

Water Demands and Supplies

Since the turn of the century, extensive water development has been carried out throughout the South Coast Region. Steady expansion of population and the economy lead to sufficient demand and financial resources to build large water supply projects for importing water to the region. In 1913, the Los Angeles Aqueduct began importing water from the Mono-Owens area to the South Coast region (a second conduit was added in 1970). In 1941, the MWDSC completed its Colorado River Aqueduct, which now provides about 25 percent of the region's supply. SWP began delivering water from the Sacramento-San Joaquin Delta to the South Coast Region in 1972. Table 7-21 shows the water budget for the region.

Table 7-21. South Coast Region Water Demand and Supply (taf)

	1995		2020	
	Average	Drought	Average	Drought
Applied Water				
Urban	4,340	4,382	5,519	5,612
Agricultural	784	820	462	484
Environmental	31	31	35	35
Total Applied Water	5,155	5,232	6,015	6,130
Supplies				
Surface Water	3,770	3,085	3,764	3,084
Groundwater	1,177	1,371	1,196	1,422
Recycled and/or Desalted	207	207	328	328
Total Supplies	5,155	4,664	5,288	4,835
Shortages	0	568	728	1,295

☞Photo: LA Aqueduct

Los Angeles Aqueduct

The Los Angeles Department of Water and Power owns and operates the LAA which diverts both surface and groundwater from the Owens Valley and surface water from the Mono Basin. The combined carrying capacity of the two aqueducts is about 780 cfs, or about 564,000 af per year. An average of 400,000 af of water is delivered through the LAA with a record 534,000 af in 1983. Court-ordered restrictions on diversions from the Mono Basin and Owens Valley have reduced the amount of water the City of Los Angeles can divert (see South Lahontan Region).

Colorado River Aqueduct

MWDSC was created in 1928 to construct and operate the Colorado River Aqueduct so that Colorado River water could be delivered to Southern California. MWDSC wholesales water supplies from the Colorado River and the SWP to water agencies throughout Southern California.

MWDSC and its 27 member agencies (see Table 7-22) serve 95 percent of the South Coast Region. Some agencies rely solely on MWDSC for their water supply, while many, like the City of Los Angeles and San Diego County Water Authority, rely on MWDSC to supplement

existing supplies. Between fiscal years 1970 and 1994, the City of Los Angeles purchased an average of 130,000 acre-feet per year from MWDSC, about 20 percent of the City's total water supply. In 1995, approximately 77 percent (396,000 af) of San Diego County Water Authority's total water supply was purchased from MWDSC.

Table 7-22
Member Agencies, Metropolitan Water District of Southern California

Member Cities	*Municipal Water Districts*	*Water Authority*
Anaheim	Calleguas	San Diego County
Beverly Hills	Central Basin	
Burbank	Chino Basin	
Compton	Coastal	
Fullerton	Eastern	
Glendale	Foothill	
Long Beach	Las Virgenes	
Los Angeles	Orange County	
Pasadena	Three Valleys	
San Fernando	West Basin	
San Marino	Upper San Gabriel Valley	
Santa Ana	Western of Riverside County	
Santa Monica		
Torrance		

MWDSC has received Colorado River water since 1941 under contracts with USBR. These contracts have allowed the diversion of 1.21 million af each year, as well as 180,000 af per year of surplus water when available. (The maximum capacity of the CRA is 1.3 maf per year.) In 1964, a U.S. Supreme Court decree, *Arizona* v. *California*, limited California's basic apportionment of Colorado River water to 4.4 maf per year. However, California was able to use the amount allocated to, but not used by, Nevada and Arizona. With completion of the Central Arizona Project and the 1996 enactment of a state groundwater banking act, Arizona projects that it will use virtually all of its apportionment for the first time in 1998. The fact that California will have to reduce its Colorado River use from current levels to 4.4 maf per year has significant

implications for the South Coast Region. (See the Issues section below and the Colorado River Region in Chapter 9). California's Colorado River use in 1996 was 5.3 maf, and has varied from 4.5 maf to 5.3 maf annually over the past 10 years.

State Water Project

Local agencies contracting with the State Water Project for part of their supplies are shown in Table 7-23.

Table 7-23

State Water Project Contractors in the South Coast Region

Agency	*Maximum Contract Entitlement (af/yr)*	*SWP Deliveries in 1995 (af/yr)*
Castaic Lake Water Agency	54,200	27,233
San Bernardino Valley Municipal Water District	102,600	696
San Gabriel Valley Municipal Water District	28,800	12,922
San Gorgonio Pass Water Agency	17,300	-0-
The Metropolitan Water District of Southern California	2,011,500	436,042
Ventura County Flood Control District	20,000	-0-

MWDSC is the largest SWP contractor with ultimate entitlement of more than 2 maf. In 1992, Castaic Lake Water Agency assumed the SWP contract of Devil's Den Water District in the Tulare Lake Region, increasing Castaic's entitlement to 54,200 af. Within the San Bernardino Valley Municipal Water District service area, groundwater is the major source of water for customers, and hence the District has used little of its SWP water. Ventura County Flood Control District also relies mostly on groundwater and has taken delivery of SWP supply only twice, during the drought in 1990 and 1991. San Gorgonio Pass Water Agency (which also serves a portion of the Colorado River Region) lacks the facilities to take delivery of SWP water, and to date has received no actual supply from the SWP.

The Department is working with the San Gorgonio Pass Water Agency and the San Bernardino Valley Municipal Water District to extend the East Branch of the California Aqueduct SGPWA, which serves the Banning Pass area of Riverside County including the communities of Banning and Beaumont, and to provide system improvements to SBVMWD.

The project will be constructed in two phases. Phase I construction will begin early in 1998 and is scheduled to be completed by the summer of 1999. Water deliveries should commence by the fall of 1999. A second phase will be constructed to serve the Mentone area if demand increases.

☞Photo: Edmonston Pumping Plant

Local Surface Water Supplies

Table 7-24 lists major local storage reservoirs in the region. Most of the largest reservoirs in the region have water supply as their primary purpose. However, several of the larger water supply reservoirs do not actually develop local supply -- they are the terminal facilities of the major conveyance facilities that import water to the region.

Table 7-24. Major Reservoirs in the South Coast Region

Reservoir Name	*Owner*	*Capacity (taf)*	*Primary Purpose*
Casitas	USBR	254	Water Supply
Lake Piru	United WCD	88	Water Supply
Pyramid	DWR	171	Water Supply
Castaic	DWR	324	Water Supply
Big Bear Lake (Bear Valley)	Big Bear MWD	73	Water Supply
Perris	DWR	132	Water Supply
Mathews	MWDSC	182	Water Supply
Vail	Rancho California WD	50	Water Supply
Henshaw	Vista ID	53	Water Supply
San Vicente	City of San Diego	90	Water Supply
El Capitan	City of San Diego	113	Water Supply
Morena	City of San Diego	50	Water Supply
Whittier Narrows	COE	67	Flood Control
Prado	COE	183	Flood Control
Seven Oaks	COE (under construction)	146	Flood Control
Eastside	MWDSC (under construction)	800	Water Supply

[1] Reservoirs with capacity greater than 50,000 acre-feet.

Table 7-25 lists the local reservoirs in MWDSC's service area with at least 10 taf storage capacity.

Table 7-25. Major Local Storage Reservoirs in MWDSC's Service Area

Member Agency/Subagency	*Reservoir*	*Storage Capacity (taf)*
Calleguas MWD	Lake Bard	10.0
Eastern MWD		
Rancho California WD	Vail Lake	51.0
Lake Hemet MWD	Lake Hemet	14.0
Las Virgenes MWD	Westlake Reservoir	10.0
City of Los Angeles	Los Angeles	10.2
	Stone Canyon	10.8
MWD of Orange County		
Irvine Ranch WD & Serrano ID	Santiago	25.0
San Diego CWA		
Vista ID	Henshaw	51.8
Helix ID	Cuyamaca Dam & Lake Jennings	18.0
City of San Diego	Barrett	38.0
	El Capitan	112.8
	Lake Hodges	33.6
	Morena	50.2
	Lower Otay	49.5
	San Vicente	90.2
	Sutherland	29.7
Sweetwater Authority	Lake Loveland	25.4
	Sweetwater	27.7
Western MWD of Riverside		
Temescal Water Company	Railroad Canyon	12.0
Total		**670.0**

SDCWA supplies water to the western third of San Diego County through water supplies from MWDSC. About 96 percent of the county's population resides within SDCWA's service area. SDCWA, a wholesale water agency, purchases imported water from MWDSC and delivers it to its 23 member agencies (Table 7-26) through two aqueducts systems. SDCWA's maximum annual delivery was 647,000 acre-feet in 1990. Local agencies' surface reservoirs provide most of San Diego County's local water supplies. Twenty-four surface reservoirs are located within its service area, with a combined capacity of approximately 569 taf. Some reservoirs are connected to SDCWA's aqueduct system and can receive imported water in addition to surface runoff. In 1995, local water sources provided 118 taf, or 23 percent of the water used in

SDCWA's service area. (Since 1980, local surface water supplies have ranged from 33 taf to 174 taf annually.)

Table 7-26. San Diego County Water Authority Member Agencies

Member Cities
- Del Mar
- Escondido
- National City
- Oceanside
- Poway
- San Diego

Water Districts
- Helix
- Otay
- San Dieguito
- Vallecitos

Municipal Water Districts
- Carlsbad
- Olivenhain
- Padre Dam
- Rainbow
- Ramona
- Rincon Del Diablo
- Valley Center
- Yuima

Irrigation Districts
- Santa Fe
- South Bay
- Vista

Public Utility District
- Fallbrook

Reservation
- Pendleton Military

Ex-Officio Member
- San Diego County

Municipal Water District of Orange County, a wholesale water agency, purchases imported water from MWDSC and delivers it to its 28 member agencies (Table 7-27) serving about 65 percent of Orange County. In December 1997, hearings are expected to begin before the Local Agency Formation Commission to merge MWDOC and Coastal MWD, the two wholesale agencies serving Orange County. Local supplies developed by individual retail agencies, primarily groundwater, presently account for about 50 percent of Orange County's water use. The primary groundwater basin is located in the northern half of Orange County.

Table 7-27. Member Agencies of Municipal Water District of Orange County

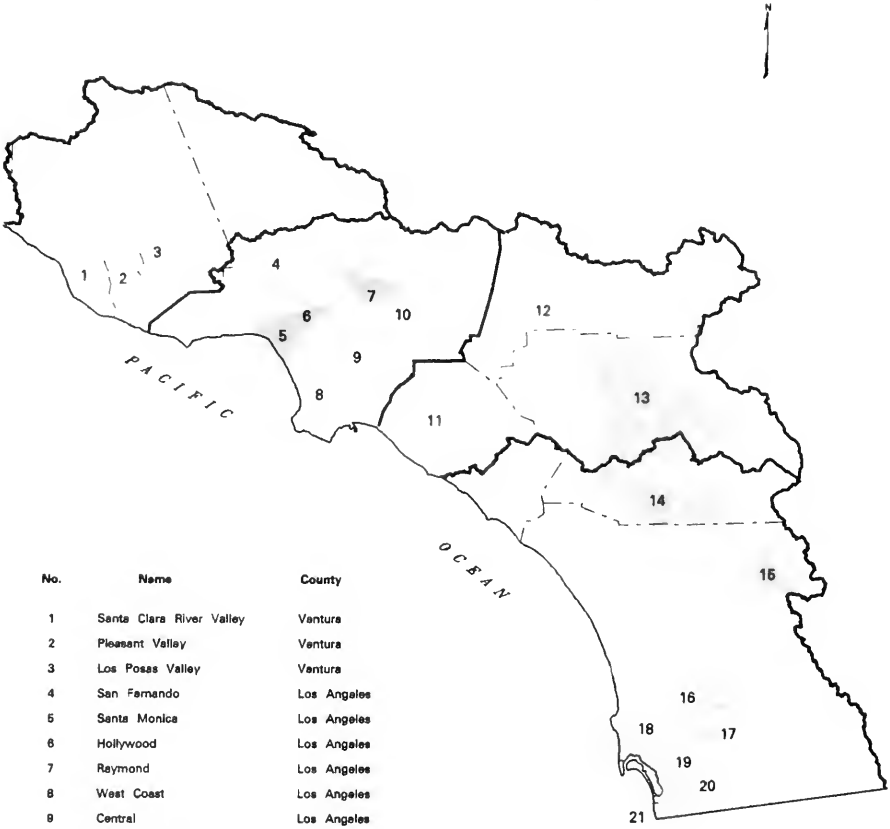
Cities	*Water Districts*	*Other*
Brea	Capistrano Valley	County of Orange
Buena Park	East Orange County	The Irvine Company
Fountain Valley	El Toro	Irvine Ranch LLC
Garden Grove	Irvine Ranch	So. California Water Co.
Huntington Beach	Los Alisos	
La Habra	Mesa Consolidated	
La Palma	Moulton Niguel	
Orange	Orange County	
Seal Beach	Santa Margarita	
Tustin	Santiago County	
Westminster	Serrano	
	Trabuco Canyon	
	Yorba Linda	

Groundwater Supplies

There are numerous groundwater basins (Figure 7-6) along the coast and inland valleys of the region. Many of these basins are actively managed by a public agency or have been adjudicated by the courts. Recharge occurs from natural infiltration along river valleys, but in many cases facilities have been constructed to recharge local, imported or reclaimed supplies. Some groundwater basins are as large as several hundred square miles in area and have a capacity exceeding 10 maf. The South Coast's current estimated annual groundwater use is about 1.2 maf. More groundwater is used in drought years when surface supplies are limited. During wetter periods, programs are in place to intentionally recharge groundwater basins. With 1995 level of development, about 100 taf is intentionally recharged in average years. In the water budget, water supplies used to recharge groundwater basins are included as an urban water demand in average years.

Table 7-28 shows adjudicated groundwater basins in the South Coast Region. In the adjudicated groundwater basins, the court appoints watermasters to oversee the court judgment. In these basins the court judgment limits the amount of groundwater that can be extracted by parties to the judgment.

Figure 7-6. South Coast Groundwater Basins



No.	Name	County
1	Santa Clara River Valley	Ventura
2	Pleasant Valley	Ventura
3	Los Posas Valley	Ventura
4	San Fernando	Los Angeles
5	Santa Monica	Los Angeles
6	Hollywood	Los Angeles
7	Raymond	Los Angeles
8	West Coast	Los Angeles
9	Central	Los Angeles
10	Main San Gabiel	Los Angeles
11	Orange County Coastal Plain	Orange
12	Upper Santa Ana Valley	Riverside, San Bernardino
13	San Jacinto	Riverside
14	Temecula Valley	Riverside
15	Warner Valley	San Diego
16	San Diego River	San Diego

No.	Name	County
17	El Cajon Valley	San Diego
18	Mission Valley	San Diego
19	Sweetwater Valley	San Diego
20	Otay Valley	San Diego
21	Tia Juana	San Diego

Table 7-28. Adjudicated Groundwater Basins in the South Coast Region

Court Name	Filed in Court	Final Decision	Watermaster	Basin Name, County
Upper Los Angeles River Area	1955	1979	Superior Court appointee	San Fernando Valley Basin (entire watershed), Los Angeles
Raymond Basin	1937	1944	Raymond Basin Management Board	Northwest part of San Gabriel Valley Basin, Los Angeles
Main San Gabriel Basin	1968	1973	9-Member Board appointed by the LA County Superior Court	San Gabriel Valley Basin, excluding Raymond Basin, Los Angeles
Central Basin	1962	1965	DWR-Southern District	Northeast part of Coastal Plain of Los Angeles County Basin, Los Angeles
West Coast Basin	1946	1961	DWR-Southern District	Southwest part of Coastal Plain of Los Angeles County Basin, Los Angeles
Puente	1985	1985	Two consultants, one representing the Walnut Valley WD and Rowland WD; and one for the City of Industry and Industry Urban Development Agency; and a third neutral party	San Gabriel Valley Basin, excluding Raymond Basin, Los Angeles
Santa Margarita River Watershed	1951	1966	U.S. District Court appointee	The entire Santa Margarita River watershed, including three groundwater basins -- Santa Margarita Valley, Temecula Valley and Cahuila Valley, San Diego and Riverside.
Santa Paula Basin	1991	1996	3 person technical Advisory Committee from United Water Conservation District, City of Ventura, and Santa Paula Basin Pumpers Association	Sub-basin of Santa Clara River, Ventura County
Chino Basin	1978	1978	Chino Basin Municipal Water District	Chino Basin, northwest part of Upper Santa Ana Valley Basin, San Bernardino and Riverside counties
Cucamonga Basin			Not yet appointed, operated as part of Chino Basin	Cucamonga Basin, north-central part of Upper Santa Ana Valley Basin, San Bernardino County
San Bernardino Basin Area	1963	1969	One representative each from Western Municipal Water District and San Bernardino Valley Municipal Water District	Northeast part of Upper Santa Ana Basin, San Bernardino and Riverside Counties

Local Water Resources Management Issues

Water Supply Reliability

The South Coast Region is the most populous in the State. Since local supplies are insufficient to meet water demands, the region imports more than 60 percent of its supply. A

natural disaster or other emergency that would curtail or limit imports to the region would be detrimental. Hence, water supply reliability is a critical issue for the region and water agencies are looking to ensure a more reliable and adequate supply in case of emergencies.

Eastside Reservoir. MWDSC provides about 60 percent of the water used by the nearly 16 million people living on the coastal plain between Ventura County and the Mexican border. To better manage its water supplies between wet and dry years, MWDSC is currently constructing Eastside Reservoir. The 800,000 af reservoir will nearly double the region's existing surface storage capacity. When completed and filled, Eastside Reservoir would provide the entire region with a six-month emergency supply after an earthquake or other disaster. It would also provide additional water supplies for drought protection and peak summer demands.

Under construction in the Domenigoni and Diamond valleys near Hemet in southwestern Riverside County, the $2 billion project consists of two main embankments to block both the east and west ends of the valleys, as well as a saddle dam located along a low point in the hills which form the northern boundary of the reservoir. The reservoir also includes a forebay and pumping plant, the 8-mile, 12-foot diameter Eastside Pipeline. After reservoir completion in 1999, it will take up to four years to fill with water imported from the Colorado River and from the SWP. Water imported from the Colorado River Aqueduct will be delivered through the San Diego Canal into the reservoir forebay and pumped into the reservoir. SWP water will be released from Lake Silverwood into Eastside Reservoir by gravity through MWDSC's new 44-mile Inland Feeder pipeline.

The Inland Feeder project is a new major conveyance facility to deliver SWP water made available by the enlargement of the East Branch of the California Aqueduct. The 43.5-mile tunnel/pipeline will provide system reliability by linking together the SWP and Colorado River systems, and will improve water quality by allowing blending of SWP and Colorado River waters.

San Diego Emergency Storage Project. SDCWA does not own or operate treatment or storage facilities. It has a contractual agreement with the City of San Diego to store up to 40,000 acre-feet of water in San Vicente and Lower Otay reservoirs. To increase local supplies that would be available during times of emergency, SDCWA has proposed an emergency storage

project that could increase the county's total water storage by 90,000 acre-feet. Use of the ESP would be limited to emergency situations, such as prolonged drought or catastrophic failure of SDCWA's pipelines during an earthquake or other disaster. Although the ESP is not a water supply development project, it does provide incidental local supply benefits by allowing capture of additional winter runoff.

Four ESP alternatives were evaluated. All involved increased surface storage and new distribution systems. Three alternatives additionally involved reservoir reoperation.

- San Vicente Stand Alone. Expand San Vicente Reservoir by raising the dam 83 feet to contain 90,100 af of emergency storage.
- Moosa Canyon Construction/Lake Hodges Reoperation. Construct a new dam at Moosa Canyon to hold 68,000 af and reoperate Lake Hodges to hold 22,100 af.
- San Vicente Expansion and Reoperation. Raise the dam by 65 feet, adding 68,000 af of emergency storage and reoperate the reservoir to provide an additional 22,100 af.
- Olivenhain Construction, Lake Hodges Reoperation, San Vicente Expansion. Build new 320 -foot high dam at Olivenhain site to create 18,000 af of emergency storage. Reoperate Lake Hodges to hold an additional 20,000 af and raise San Vicente Dam by 54 feet to hold an additional 52,100 af.

The preferred project alternative is the Olivenhain-Hodges-San Vicente system. A new reservoir would be constructed about 1 mile northwest of Lake Hodges at Mount Israel in conjunction with Olivenhain Municipal Water District. The new Olivenhain Reservoir would be connected to Lake Hodges by a 1.5-mile pipeline. San Vicente Dam would be raised from 234 feet to 288 feet. The Olivenhain-Hodges-San Vicente system would add 90,100 af of emergency storage capacity. The final EIR and EIS were certified in 1997.

Meanwhile, Olivenhain Municipal Water District is proceeding with plans to construct a reservoir at the Mount Israel site. Without participants such as SDCWA, the district would have constructed a 6 taf to 8 taf reservoir on Box Canyon Creek for emergency and operational supply.

Management of California's Colorado River Water

A major water management issue facing the South Coast Region (see Colorado River Region in Chapter 9 for a complete discussion) is California's use of Colorado River water in

excess of its basic annual apportionment of 4.4 maf. In the past, Arizona and Nevada were not using the full amount of their annual apportionments, and California was able to use the amount apportioned to, but not used by, Nevada and Arizona.

Discussions among the seven Colorado River basin states over changes to Colorado River operating criteria and ways for California to reduce its use of Colorado River water have been ongoing. The other basin states have indicated that a temporary or short-term change to Colorado River operating criteria could be acceptable to them as part of a package of actions for California to reduce its annual use to 4.4 maf. Discussions have been underway among California Colorado River water users to develop a consensus position on these issues.

Options that would keep MWDSC's Colorado Aqueduct flowing at its full capacity of 1.3 maf in the future are discussed in the following section. (At a California limitation of 4.4 maf, MWDSC would only be able to exercise its fourth priority right to 550 taf, as compared to maximum aqueduct capacity of 1.3 maf.) A more detailed review of Colorado River issues is provided in Chapter 9.

Mono Basin

The City of Los Angeles' water diversions from Mono Basin have lowered Mono Lake's water level by more than 40 feet since 1941 and also increased the lake's salinity. (See the South Lahontan Region in Chapter 10 for more detailed discussion on the Mono Lake issue.) In 1994, the SWRCB adopted Water Right Decision 1631 amending the City of Los Angeles' water right licenses for diverting water from Mono Basin. The decision restricts diversions from the basin to restore the lake level to 6,392 feet above sea level over an approximate 20-year period. Average exports during the 20-year period are estimated at 12,300 af/year, a reduction from an average of 83,000 af/yr from the Basin between 1974 and 1989.

Restoration of Coastal Wetlands and Estuaries

Ballona Wetlands Preserve. Although the majority of California's wetlands habitat is found in the Central Valley and San Francisco Bay area, there are significant wetlands in the South Coast, as described below. The Ballona wetlands is one of the more well-known South Coast wetlands.

The Ballona Wetlands Preserve, located in Los Angeles County near Marina Del Rey, is one of the few tidal marshes in Southern California. It is a complex of estuary, lagoon, salt marsh, freshwater marsh, and dune habitats. It provides nesting grounds for migrating water-fowl, supports a variety of plant, fish, and animal life, and is home to two endangered species -- Belding's Savannah sparrow and the California least tern. The present Ballona wetlands is a small remnant of what existed in the early 1800s, when the wetlands comprised more than 2,000 acres. At the present time, it has been reduced to a little more than 180 acres.

The Ballona Wetlands Preserve is the subject of a long-running debate among private property owners and environmental groups that began in 1984 when the California Coastal Commission approved a land use plan to develop the wetlands. In the years that followed, the plaintiffs and defendants have worked out a settlement to the lawsuit. The settlement provides for:

- Major restoration of 190 acres of salt marsh habitat. Plans are underway to provide the eastern portion of the salt marsh with full tidal flow and expanded habitat for sub-tidal and mudflat organisms. The western portion would be provided with muted tidal flow to protect and enhance existing salt marsh habitat for pickleweed and the Belding's Savannah sparrow.
- A 34-acre freshwater marsh.
- A 25-acre corridor of riparian habitat along Centinela Creek. This area will potentially provide appropriate vegetation for Bell's least vireo and a wide variety of other birds which favor riparian trees for nesting.
- Restoration of 48 acres of upland, bluff edge, and coastal strand habitat.

When completed, the Ballona Wetlands Preserve will be one of the largest wildlife sanctuaries in any major U.S. city.

Santa Monica Bay. Santa Monica Bay extends about 50 miles from Point Dume to Palos Verdes Point. A coordinated effort to improve the Santa Monica Bay ecosystem began with establishment of the Santa Monica Bay Restoration Project. SMBRP was accepted into the Clean Water Act's National Estuary Program in 1988, and was charged with assessing the bay's

problems and with producing a bay restoration plan. Implementation of the plan, approved by the Governor in 1994, and by the Administrator of USEPA in 1995, is currently underway.

Flood Control

As noted earlier, groundwater constitutes most of the local water supply in the region. Local surface water resources are relatively limited. In the Los Angeles-Orange County coastal strip, most of the rivers and streams that drain to the Pacific Ocean have been developed primarily for flood control purposes, rather than for surface water supply. (Some of these reservoirs are operated to provide surface flows for groundwater recharge. A few of the existing flood control reservoirs are now being evaluated for their potential to provide some, albeit small, water supply benefits, usually by reoperation of the facilities to enhance groundwater recharge and provide limited year-round storage. Several of these facilities are discussed in the water management options section. Below, we discuss a few examples of flood control-related water management issues in the region.

Los Angeles River. The USACE, in cooperation with Los Angeles County, has constructed an extensive network of flood control facilities on the Los Angeles River, which passes through one of the most intensively urbanized areas in the South Coast Region. (In fact, discussions on transportation issues in the region sometimes mention converting the existing concrete channel into a freeway or high-occupancy-vehicle transit route.) USACE's flood control facilities on the Los Angeles River and its tributaries include five major dams, 22 debris basins, and 470 miles of channel modifications.

Flood control operations in coastal Southern California, and their interaction with reservoir operations for water supply purposes, typically differ from those in Northern California. The Sierran reservoirs in the Central Valley that provide most of California's developed surface water supply are, as a broad generalization, operated from a water supply standpoint to manage snowmelt runoff that occurs over a period of several months, and to hold large volumes of carry-over storage throughout the year. Flood control reservoirs in coastal Southern California are operated to provide short-term detention (days to weeks) of peak flows from rainfloods. Many of these reservoirs impound ephemeral streams, or streams whose runoff is so small that little water supply benefit is available.

USACE's facilities on the Los Angeles River were designed to provide temporary detention of peak flows, to allow the flows to be released to the Pacific Ocean without exceeding downstream channel capacities. Continually increasing water demands in the South Coast Region have prompted reevalution of the operations of some of the larger flood control facilities, to determine if their operations could be modified to provide limited additional water supply. One example is a 67 taf flood control detention basin impounded by Whittier Narrows Dam on Rio Hondo, a Los Angeles River tributary, described in the following water management options section.

Santa Ana River. The Santa Ana River has been channelized for almost its entire length throughout the highly urbanized part of Orange County, from the river's mouth near Costa Mesa upstream to the vicinity of Placentia. Upstream, Prado Dam in the Santa Ana Mountains impounds a large flood control detention basin. The USACE has constructed several flood control features of the Santa Ana mainstem project, with the most recent facility of that project being Seven Oaks Dam. The 550-foot high Seven Oaks Dam, under construction now, is located about 35 miles upstream from Prado Dam and will have a gross storage capacity of about 146,000 af. As constructed, the 134-foot high earthfill Prado Dam has a storage capacity of 217,000 af. Future plans entail enlarging Prado's capacity to 363,000 af of flood control storage. After Prado Dam is enlarged, the Orange County Water District would propose to raise the reservoir's minimum pool level, to capture runoff for water supply purposes. This enlargement in storage would be accompanied by development of a new flood forecasting system for the reservoir. The District is currently undertaking a feasibility study with USACE to evaluate potential water supply gains from Prado's enlargement. It is estimated that allowing additional storage at Prado by modifying its flood control operation would provide an additional 3,000 af to 5,000 af of annual supply for groundwater recharge.

Water Quality Issues Associated with Imported Water

Imported water from the Colorado River and the SWP is a major source of supply for the South Coast Region. A critical factor in determining the usability of these supplies is the water quality. The total dissolved solids concentration in imported water has water management implications for the region, affecting the feasibility of water recycling and groundwater recharge

programs. Because residential use of water adds TDS concentration, water recycled from a moderately high TDS source water can result in unacceptably high TDS concentrations. Groundwater recharge may be affected because some groundwater basins have water quality limitations on the use of high TDS recharge. These limitations are generally the result of water quality objectives developed by Regional Water Quality Control Boards.

Mineral concentrations in Colorado River water are higher than those found in the water taken from the Delta. The TDS of the Colorado River Aqueduct supply currently averages 650 mg/L while SWP supply has a TDS of about 350 TDS mg/L. TDS of the CRA supply is expected to increase to about 700 mg/L even with planned salinity control measures for the Colorado River. Colorado River water is generally blended with SWP water to reduce TDS concentrations. As discussed in Chapter 3, SWP supplies contain disinfection by-product precursors, from bromides in seawater and from organics in Sacramento-San Joaquin Delta soils.

MWDSC/USBR Salinity Management Study

In 1996, USBR and MWDSC began a joint salinity management study to develop information to support adoption of regional salinity management policies by MWDSC and to coordinate interagency action to solve salinity problems. The study's initial phase focuses on identifying problems and salinity management needs of MWDSC's service area.

According to Phase I work performed for the study, the average salinity level in MWDSC's Colorado River water in 1996 was about 700 mg/L of TDS, and MWDSC's SWP supplies averaged about 300 mg/L. The City of Los Angeles' water supply from the eastern Sierra Nevada was significantly lower in salinity, typically about 100 mg/L. TDS levels in local groundwater supplies in South Coast Region vary considerably, ranging from 200 mg/L (Cucamonga Basin near Upland) to more than 1,000 mg/L (Arlington Basin near Corona). About 11 percent of the regional groundwater production has TDS concentrations in excess of 1,000 mg/L. An additional 11 percent of production has TDS in excess of 500 mg/L.

Table 7-29. TDS of Groundwater Supply

TDS Concentration (mg/L)	Annual Production (maf)	Percent
Less Than 500	1.06	78
500 to 1,000	0.15	11
Greater than 1,000	0.15	11
	1.36	**100**

Local sources of salinity also contribute significantly to the problems within the region. Urban uses of water contribute between 250 to 500 mg/L of salts into the wastewater. Key sources of local salts include the use of water softeners (typically contributing from 5 to 10 percent of the salt load) and industrial processes. See Table 7-29.

The long-term salt balance of South Coast groundwater basins is an important management problem. Smaller basins like the Arlington and Mission groundwater basins were abandoned for municipal supply because of high salinity levels. Only recently have these basins been restored to use through construction of desalting projects. Starting in the early 1970s with initial SWP deliveries to the South Coast, blending of SWP and Colorado River supplies, or using the SWP's relatively low TDS supplies for groundwater replenishment, became a goal in some areas. However, without an ocean outfall or stream discharge, some inland agencies that reuse wastewater have salt accumulation problems in their groundwater basins. Some inland agencies have access to a brine line for exporting salt and concentrated wastes to a coastal treatment plant and ocean outfall, while others have not found construction of a brine line economical.

The apparent dilemma for the region is that during droughts when the use of recycled water projects and marginal quality groundwater are most important, some of these local supplies may be constrained by water quality problems. Beginning in the mid-1980s, with the expansion of water recycling programs, concerns about wastewater TDS have grown significantly. In general, TDS more than 1,000 mg/L is a quality problem for irrigation and industrial reuse customers.

The study's second phase will evaluate TDS management options such as desalting source supplies (Colorado River), imported water blending strategies, desalting at the point of use (brackish groundwater and at wastewater treatment plants), dilution at point of use, source

control regulations, and corresponding changes in Regional Water Quality Control Board basin plan requirements.

Groundwater Issues

San Gabriel and San Fernando Valleys. Groundwater contamination in the San Gabriel Valley and San Fernando Valley basins has come from many sources dating back to the 1940s. Each basin has four areas on the U.S. Environmental Protection Agency's Superfund list.

More than 30 square miles of groundwater under the San Gabriel Valley Basin may be contaminated. Contamination of the groundwater by volatile organic compounds was first detected in 1979 when Aerojet Electrosystems in Azusa sampled nearby wells in Valley County Water District. Subsequently, DHS initiated a well sampling program to assess the extent of contamination. By 1984, 59 wells were found to be contaminated with high levels of VOCs. The most prevalent are trichloroethene, perchloroethylene, and carbon tetrachloride.

The San Gabriel Basin Water Quality Authority was created by the State Legislature in 1993 to be the agency responsible for remediating groundwater contamination in San Gabriel Valley. WQA's mission is to plan and implement groundwater quality management programs and to protect the basin from future contamination. The WQA is under the direction and leadership of a 5-member board, comprised of one member from each of the overlying municipal water districts, one from a city with prescriptive water pumping rights and one from a city without prescriptive water pumping rights. The three municipal water districts are San Gabriel Valley MWD, Three Valleys MWD, and Upper San Gabriel Valley MWD.

Currently, four areas of the basin are of concern: Whittier Narrows, Puente Basin, Baldwin Park/Azusa, and El Monte/South El Monte. The WQA is involved in groundwater cleanup projects in these areas. The Whittier Narrows and Puente Basins are also being managed by USEPA under its Superfund program. An additional concern is that contamination in the South El Monte area might migrate from the San Gabriel Basin through the Whittier Narrows and into the Central Basin.

The Arrow Well Treatment Plant in Baldwin Park was the first project implemented by the WQA, utilizing a $1.3 million construction grant from SWRCB. The project, completed in 1992, extracts about 3 taf per year of contaminated groundwater, treats the water, and distributes

it to customers. The Big Dalton Well Treatment Project is the second in a series of WQA projects focusing on contamination problems in the Baldwin Park area. The new facility will form part of a three-well barrier to stop the migration of polluted groundwater. The Big Dalton Well Treatment Facility is designed to extract and treat approximately 4 taf of contaminated groundwater per year. The Monrovia Wells project will treat approximately 4.6 taf of contaminated groundwater per year with airstripping. The project will give the City of Monrovia the ability to use water from contaminated aquifers while preventing the spread of contamination to adjacent clean aquifers. In 1996, legislation was enacted extending WQA's to authorization work on groundwater remediation in the San Gabriel Basin through July 1, 2002.

In the San Fernando Valley, about 50 percent of the water supply wells in the eastern portion of the basin were found to be contaminated with volatile organic compounds. Many of the wells have been shut down. The basin provides drinking water to Los Angeles, Burbank, Glendale, and La Crescenta. The RWQCB is investigating area-wide sources of groundwater contamination for four Superfund sites in the San Fernando Valley Basin. Interim clean-up measures include groundwater pumping and treatment.

San Bernardino Valley. As late as the 1940s, the lowest portion of San Bernardino Valley was composed mainly of springs and marshlands. Downtown San Bernardino is located over a confined aquifer which experiences high groundwater levels. Buildings have experienced seepage of water into basements or ground floors. High groundwater conditions increase soil liquefaction potential in an area that could be affected by movement along local segments of the Cucamonga, San Jacinto, or San Andreas faults. The presence of unreinforced masonry buildings (many of which have not received seismic upgrades) over the confined aquifer increases the risk of damage in the event of liquefaction.

The Bunker Hill Basin Groundwater Extraction Project involves pumping groundwater from the basin with the intent of lowering groundwater levels, thereby reducing seismic risks. The water could potentially be sold to help offset the pumping and other costs of the project. Extraction of groundwater for this project will not exceed the perennial yield of the San Bernardino Basin (which includes both the Bunker Hill and Lytle Creek basins). The ultimate goal of this water extraction project is to reduce the unacceptably high groundwater levels in the

basin. A suggested minimum depth target of 30 feet below ground surface in the confined zone would minimize the risk of liquefaction and other adverse impacts associated with high groundwater. One plan being considered is for San Bernardino Valley Municipal Water District to pump between 20,000 and 70,000 af per yr, with larger volumes being extracted as necessary after exceptionally wet seasons.

Ventura County. Groundwater is the main water supply for irrigation and urban use over much of the coastal plain of Ventura County (including the Oxnard Plain). As a result of increasing water demand, groundwater aquifers underlying the plain have been overdrafted. Seawater intrusion was initially observed in the late 1940s, following the widespread development of agriculture and food processing on the Oxnard Plain. Recent estimates of overdraft on the Oxnard Plain are 2,000 af/year in the upper basin (Oxnard and Mugu Aquifers), and 10,000 af/year in the lower basin (Hueneme, Fox Canyon, and Grimes Canyon Aquifers).

The Fox Canyon Groundwater Management Agency was formed to manage groundwater resources underlying the Fox Canyon aquifer zone. To eliminate overdraft in all aquifer zones, the agency adopted ordinances requiring meter installation on wells pumping more than 50 af per year. The objective of the ordinances is to limit the amount of groundwater that can be pumped and to restrict drilling of new wells in the North Las Posas Basin. In 1991, United Water Conservation District completed construction of the Freeman Diversion improvement project on the Santa Clara River. The improved structure increases average annual diversions from 40,000 af to 57,000 af. The diverted water is used for groundwater recharge and agricultural irrigation, thereby reducing agricultural groundwater demand.

In an effort to prevent degradation of the Ojai groundwater basin, a coalition of growers, public agencies, water utilities, and pumpers decided in early 1990 to seek legislation to form the Ojai Basin Groundwater Management Agency. Its activities include implementing agency ordinance, monitoring key wells, determining amounts of extraction, amounts of groundwater in storage, and operational safe yield, surveying land use within the agency's boundaries, compiling water quality data, and recharging the basin.

Southern California Comprehensive Water Reclamation and Reuse Study

In 1993, USBR, seven Southern California municipalities and water agencies, and the Department adopted a plan of study to evaluate the feasibility of regional water recycling in Southern California. Regional planning would take advantage of potential surpluses in recycled water which could serve needs in areas throughout the Southern California coastal plain and inland valley areas. The plan of study calls for a three-part, six-year comprehensive effort to identify a regional recycling system and develop potential capital projects.

The Department and USBR are to cooperate with the following seven agencies to conduct this comprehensive regional planning effort:

- Central and West Basin Municipal Water Districts
- City of Los Angeles
- City of San Diego
- Metropolitan Water District of Southern California
- San Diego County Water Authority
- Santa Ana Water Project Authority
- South Orange County Reclamation Authority

The SCCWRRS' goal is to identify opportunities and constraints associated with maximizing water recycling in Southern California. SCCWRRS has identified regional and area-wide water recycling potential for 20 and 50 year planning horizons. A regional data base is being used for analyzing alternatives using an economic distribution model. This model can be used to maximize the allocation of recycled water at minimum cost throughout the region.

Water Transfers

The South Coast Region is highly urbanized and the region relies substantially on imported water. Water wholesalers serving the region expect to acquire part of their future supplies from new water transfers, using the Colorado River Aqueduct and California Aqueduct to convey the acquired water.

A difficulty associated with obtaining future supply from water transfers -- as opposed to from fixed facilities such as reservoirs or wastewater reclamation plants -- is the greater uncertainty involved in forecasting future contractual arrangements for transfers. An urban

agency may plan to acquire some quantity of water from agricultural users in the Central Valley or the Colorado River Region, but terms and conditions of those transfers are subject to negotiation with potential sellers and the availability of conveyance. There are many ways to structure a transfer arrangement -- long-term agreements for base year transfers that occur every year regardless of hydrology, drought year transfers tied to specific hydrologic criteria, or transfer options that may be exercised based on negotiated criteria. Transfers may also be accomplished through short-term (e.g., one year or less) agreements on the spot market. Of particular note in the South Coast Region, local agencies are planning to use water transfers to constitute part of their base or core supplies, a change from past years when transfers were viewed as primarily drought year supply.

An example of a proposed base year transfer is the San Diego County Water Authority/Imperial Irrigation District transfer now under negotiation. (This proposed transfer is described in detail in Chapter 9.) The two agencies entered into a MOU in 1995 to explore potential transfer arrangements associated with a long-term transfer of up to 200 taf per year. SDCWA would need to use MWDSC's Colorado River Aqueduct to convey the transferred water to the South Coast Region. The conditions under which this wheeling would occur, and the cost to be charged for wheeling, have been a subject of discussion between SDCWA and MWDSC. MWDSC has not yet used its aqueduct to wheel water for others -- unlike the conveyance for others which has been provided in CVP and SWP facilities.

Mexican Border Environmental Quality Issues

Tijuana's excess sewage has plagued San Diego area beaches since the 1930s. During frequent failures of Tijuana's inadequate, antiquated sewage treatment system, millions of gallons of raw sewage have been carried across the border through the Tijuana River to its estuary in San Diego county. San Diego's first attempt to alleviate this problem was in 1965, when the city agreed to treat Tijuana's waste on an emergency basis. In 1983, the United States and Mexico signed an agreement stating that Mexico would modernize and expand Tijuana's sewage and water supply system and build a 34 mgd sewage treatment plant. Mexico received a grant for $46.4 million from the Inter-American Development Bank to help finance the expansion and was to spend an additional $11 million to build the wastewater treatment plant, 5 miles

south of the International Border. Phase 1 of the facility was completed in January 1987. The plant became fully operational in 1988.

In July 1990, the United States and Mexico, through the International Boundary and Water Commission, agreed to the construction of international wastewater treatment facilities in the United States to solve the continuing border sanitation problem. These facilities included the construction of a 25 mgd secondary treatment plant at a site just north of the international border and a 3.5 mile ocean outfall. Construction of the first phase of the international plant, a 25 mgd advanced primary treatment plant is being completed. Construction of the secondary phase of the International plant is on hold pending the completion of a supplemental environmental impact statement on alternative methods of secondary treatment. The second phase is expected to be complete by the end of December 2000.

The EPA and IBWC have completed a SEIS on interim options for discharge of effluent from the international plant prior to completion of the ocean outfall and the secondary treatment component of the plant. The preferred option is a combination of discharging the effluent to the City of San Diego's Metropolitan Sewerage System and constructing a detention basin to hold flows for discharge during off peak hours.

Water Management Options for South Coast Region

Southern California's challenge in managing its water resources is driven by one of the most fundamental realities of the West --- it is an arid region. The major water agencies in the South Coast Region are extensively involved in water resources management planning. Local water agencies are working to identify and evaluate water management options that can meet their water planning objectives.

A mixture of water management options, including statewide options such as improving SWP reliability, will be needed to make up California's reduced supply from the Colorado River and to offer long-term reliability to the region. Water management options considered for achieving this goal are discussed below and listed in Table 7-30.

Table 7-30. South Coast Region Options Comprehensive List

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to 0.8ETo	Retain	
	Residential Indoor Water Use	Defer	A low level of water use has already been achieved.
	Interior CII Water Use	Retain	
	Distribution System Losses	Defer	A low level system losses has already been achieved.
Agricultural			
	Seasonal Application Efficiency Improvements	Defer	No substantial depletion reductions attainable.
	Flexible Water Delivery	Defer	No substantial depletion reductions attainable.
	Canal Lining and Piping	Defer	No substantial depletion reductions attainable.
	Tailwater Recovery	Defer	No substantial depletion reductions attainable.
Modify Existing Reservoirs/Operations			
	Reoperate Prado Dam	Retain	
	Reoperate Hansen and Lopez Dams	Retain	
	Reoperate Santa Fe and Whittier Narrows Dams	Retain	
New Reservoirs/Conveyance Facilities			
	Freshwater Reservoir in Long Beach Harbor	Retain	
	New Aqueduct from Imperial Valley to San Diego	Defer	Interstate issues.
Groundwater/Conjunctive Use			
	Local Groundwater Banking/Conjunctive Use	Retain	
Water Transfers/Banking/Exchange			
	Colorado River Water Transfers/Interstate Banking (part of Colorado River 4.4 plan)	Retain	
	MWDSC / Arvin Edison WSD Groundwater Banking	Retain	
	Castaic Lake Water Agency	Retain	
Water Recycling			
	March Air Force Base	Retain	
	Carbon Canyon Reclamation Project-Phase 1	Retain	
	Reclamation Distribution System	Retain	
	Upgrade-Padre Dam W.R. Facilities	Retain	
	Whittier Narrows Recreation Area	Retain	
	T-Plant Filter Washwater Recycling Project	Retain	
	Phase 3 & 4 Reclamation Expansion	Retain	
	Puente Hills/Rose Hills Reclaimed Water District System	Retain	
	Orange County Regional Reclamation Project	Retain	
	Lower Sweetwater River Demineralization Project	Retain	
	Regional Plant No. 4 Outfall Project	Retain	
	City of West Covina	Retain	
	Santa Margarita Live Stream Discharge	Retain	

Table 7-30. Continued

Castaic Lake Water Agency Reclaimed Water Master Plan	Retain
Esteban Torres Water Recycling Project	Retain
Esteban Torres Water Recycling Project	Retain
West Basin Recycling Project-Phase 2	Retain
Reclaimed Water System	Retain
Expanded Carbon Canyon Reclamation Project	Retain
Irrigation & Industrial Projects	Retain
Alamitos Barrier Recycled Water Project	Retain
Dominguez Gap Barrier Recycled Water Project	Retain
Irvine Ranch Water District	Retain
West Los Angeles Extension	Retain
Dove Canyon Weather Recovery System	Retain
East Valley Water Recycling Project	Retain
City of Escondido Regional Water Recycling Program	Retain
Lower Moosa Canyon W.R.F.-Expansion	Retain
Carlsbad Water Reclamation Plan-Encina Basin-P2	Retain
South Bay Water Reclamation Project	Retain
North San Diego County Reclamation Project Phase 2	Retain
North City Reclamation Plant-Poway Resources	Retain
San Elijo Joint Powers Authority	Retain
Olivenhain/Kelwood Reclamation Project	Retain
Green Acres-Phase 2	Retain
San Pasqual Groundwater Management Program	Retain
Central City/Elysian Park Water Recycling Project	Retain
Central Valley Water Reclamation Facility	Retain
Verdugo-Schol-Brand Project	Retain
Alamitos Barrier	Retain
San Elijo Joint Powers Authority WRF	Retain
Los Angeles Harbor Water Recycling Project	Retain
Headworks Water Recycling Project	Retain
North City Reclamation Plant Project	Retain
Water Repurification Project	Retain
Reclamation Project I	Retain
El Toro Water District Reclamation	Retain
Westside Water Recycling Project	Retain
Sepulveda Basin Water Recycling Project	Retain
Carbon Canyon Water Reclamation Facility	Retain

Table 7-30. Continued

Desalination		
Brackish Groundwater		
Huntington Beach Colored Water	Retain	
IRWD Colored Water Treatment Project	Retain	
Laguna Beach GW Treatment Project	Retain	
Mesa Colored Water Project	Retain	
Oceanside Desalter No. 2	Retain	
OCWD Undetermined Colored Water Projects	Retain	
Corona/Temescal Basin Desalter	Retain	
Otay/Sweetwater Desalter	Retain	
Perris Basin Desalter	Retain	
Rubidoux/Western Desalter	Retain	
San Dieguito Basin Desalter	Retain	
San Juan Basin Desalter No. 2	Retain	
San Pasqual Basin Desalter Windchester/Hemet Desalter	Retain	
Santee/El Monte Basin Desalter	Retain	
Sweetwater Desalter No.2	Retain	
Tijuana River Valley Desalter	Retain	
Torrance Elm Ave. Facility	Retain	
West Basin Desalter No. 2	Retain	
West Basin Desalter No. 3	Retain	
Western/Bunker Basin Treatment Project	Retain	
Winchester/Hemet Desalter	Retain	
Seawater		
Reverse Osmosis Facilities at South Bay Power Plant	Retain	
Reverse Osmosis Facilities at Encina Power Plant	Retain	
Reverse Osmosis Facilities at Alamitos Power Plant	Retain	
Multiple-effect Distillation Process	Retain	
Other Local Options		
-----	-----	-----
Statewide Options		
CALFED Bay / Delta Program	Retain	
SWP Interim South Delta Program	Retain	
SWP American Basin Conjunctive Use Program	Retain	
SWP Supplemental Water Purchase Program	Retain	
Drought Water Bank	Retain	
Enlarge Shasta Lake	Retain	

Water Conservation

Urban. The urban water supply forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. Reducing outdoor water use to 0.8 ET_0 in new development would attain about 140 taf per year of depletion reductions, while extending this measure to include existing development would reduce depletions by about 500 taf per year. Reducing commercial, institutional, and industrial water use by 2 percent and 3 percent would attain 20 taf and 25 taf of depletion reductions per year, respectively. The residential indoor water use and distribution system options were deferred for the South Coast Region because the region has, on average, attained the values used in this Bulletin for these conservation options.

Agricultural. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Agricultural water conservation options are limited in the region because of the relatively high seasonal application efficiencies that currently exist, and the reliance on high cost, pressurized potable water or groundwater. Improving irrigation management to raise seasonal application efficiencies to 76, 78 and 80 percent in the South Coast would only reduce depletions slightly, less than 1 taf. Flexible water deliveries is deferred because most of the water applied for agriculture is delivered on-demand in the region. Canal lining and piping is deferred because of the absence of open canal systems for the transport and delivery of irrigation water in the region. The spill recovery and tailwater systems option is deferred because of the relatively small acreage under furrow or border irrigation systems in the region. Evapotranspiration reduction is deferred because of the lack of traditional crop rotational schemes that might include more fallowing.

Reoperation of Flood Control Reservoirs

The USACE operates flood control reservoirs in the Los Angeles and San Gabriel river drainages of Los Angeles County. Water conservation benefits could be realized if pools were established behind these reservoirs to temporarily impound waters during storms for later release to downstream recharge facilities. The Los Angeles County Department of Public Works and USACE are evaluating the potential for reoperation of USACE flood control reservoirs. The

preliminary studies to date have indicated that an additional 17,000 af of conservation storage is possible, and USACE is currently performing a feasibility study expected to conclude in 1998.

Prado Dam. As discussed in the water management issues section, construction of Seven Oaks Dam on the Santa Ana River and pending enlargement of the existing Prado Dam create an opportunity to reoperate Prado Dam to provide some limited water supply storage in Prado Reservoir. It is estimated that allowing additional storage at Prado by modifying its flood control operation would provide an additional 3,000 to 5,000 af of annual supply for groundwater recharge.

Hansen and Lopez Dams. Hansen Dam on Tujunga Wash and Lopez Dam on Pacoima Wash are small USACE flood control detention reservoirs (essentially debris basins) located on adjoining drainages in Los Angeles County, in the San Gabriel Mountains above Pacoima. The combined storage capacity of the two reservoirs is about 25 taf. Los Angeles County has cooperated with USACE in completion of a reconnaissance study (1994) and preparation of an ongoing feasibility-level study to evaluate possible water supply benefits from reoperating the reservoirs to provide limited water supply storage. The feasibility study is scheduled to be completed in 1998.

Santa Fe and Whittier Narrows Dams. Santa Fe Dam (32 taf storage capacity) on the San Gabriel River and Whittier Narrows Dam (67 taf storage capacity) on Rio Hondo are USACE dams in that impound flood control detention basins in Los Angeles County. Los Angeles County has cooperated with USACE in completion of a reconnaissance study (1994) and preparation of an ongoing feasibility-level study to evaluate possible water supply benefits from reoperating the reservoirs to provide limited water supply storage. The feasibility study is scheduled to be completed in 1998. The feasibility study is examining allowing a permanent water conservation pool to be maintained at Santa Fe Dam, and expanding the existing conservation storage pool at Whittier Narrows.

New Reservoirs

In an average year, about 200,000 af of storm runoff from the Los Angeles River flows to the ocean. The freshwater reservoir project would include an inflatable weir across the Los Angeles River near its mouth, to direct some of the storm flows into intakes constructed

alongside of the existing river levees. From the intakes, the storm flow would be pumped or flow by gravity via culverts or tunnels to an offshore reservoir. The reservoir site would be in the vicinity of the existing Long Beach Breakwater in San Pedro Bay. Reservoir dikes would be constructed in the bay with a diaphragm wall constructed through the dikes to prevent leakage of freshwater through the walls of the dam. A bulb of freshwater would be maintained at the bottom of the reservoir to repel seawater. The reservoir could be sized to store 100 taf to 300 taf of storm water during the wet season. This captured storm water could subsequently be distributed for a number of uses, with the most likely use being groundwater recharge.

The option analyzed consisted of a 100 taf reservoir sited within San Pedro Bay supplying the Montebello Forebay spreading grounds with 71 taf to 129 taf per year. The annual cost of the water would be about $1,700 /af at 71 taf of supply, decreasing to $1,000 per af at 129 taf of supply. Expansion of the project to capture all stormwater runoff would maximize the reservoir yield at 172,000 af per year, decreasing annual cost to $800 /af. A final draft of the feasibility study was issued in May 1997.

Groundwater/Conjunctive Use

As a result of MWDSC's seasonal storage service pricing program, local agencies are storing imported water in groundwater basins to increase groundwater production during the summer season and dry years. It is estimated that an average of 100,000 af per year of groundwater supply is now produced as a result of MWDSC's discount pricing for winter season deliveries. The program provides imported water at an average discount of $125/af during the winter season. This discount is an inducement to local agencies to pump more groundwater during the summer season (reducing peaks on MWDSC's system) and during dry years when imported supplies are scarcer.

As an option, MWDSC has identified the potential for 200,000 acre-feet of additional groundwater production during dry years. To accomplish this additional drought year production, about 600,000 af of dedicated storage capacity within the local basins may be required. The cost of the water would be about $350/af. As part of MWDSC's plans to develop additional supplies from local banking, the district is working with Calleguas Municipal Water District, one of its member agencies. The Las Posas Basin aquifer storage and recovery project would

develop up to 250,000 af of storage in the lower aquifer system of the Las Posas Basin. MWDSC and Calleguas are currently finalizing principles for a water management service agreement.

Water Transfers

Colorado River Region Transfers. As described in Chapter 9, there are a number of potential options for making water from the Colorado River Region available for transfer to the South Coast Region. (See Chapter 9 for a detailed discussion of Colorado River water allocation and future water management options.) However, these options must be implemented in concert with California's reducing its use of Colorado River water to its basic apportionment of 4.4 maf. Measures that would simply transfer existing uses from the Colorado River Region to the South Coast Region do not reduce use of Colorado River water.

We assume in the water balance for the South Coast Region that the region's supply base from the Colorado River will be limited to MWDSC's fourth priority right of 550 taf contained within California's basic 4.4 maf apportionment. Water agencies in the South Coast Region will attempt to negotiate water transfers to keep the Colorado River Aqueduct flowing at its maximum capacity of 1.3 maf. One such transfer is the existing MWDSC/IID conservation agreement, described in Chapter 3, forecasted to supply 106 taf to the South Coast in 2020. (Under certain conditions specified in the agreement, Coachella Valley Water District would receive 50,000 af of this amount in some years. For the purposes of this Bulletin, the 106,000 af has been shown in the water budgets as a South Coast Region supply in 2020.)

Construction of additional conveyance capacity from the Colorado River Region to the South Coast area has been a recent subject of discussion. Proposition 204 provides funding for a feasibility study of a new conveyance facility from the Colorado River to the South Coast. New conveyance facilities mentioned have included an aqueduct from the Imperial Valley area to San Diego, and a joint Tijuana/ San Diego aqueduct. These new conveyance facilities have been deferred from evaluation in Bulletin 160-98 because it does not appear that they would be constructed within the Bulletin's planning horizon, due to the concerns expressed by other Colorado River Basin states about a new California diversion facility on the river.

SDCWA and IID have been discussing a potential transfer of water saved due to extraordinary conservation measures within IID. The agencies executed a September 1995 MOU concerning negotiation of a transfer agreement, and subsequently developed proposed terms and conditions of a transfer. Terms and conditions for a proposed agreement with a 75-year term were distributed for review to the agencies' water users and interested parties in 1996. As proposed, an initial transfer of 20 taf would begin in 1999, with the annual quantity of transferred water increasing to 200 taf after 10 years. SDCWA and IID are currently negotiating final terms for the transfer. In order to transfer the acquired water, SDCWA (a member agency of MWDSC) must negotiate a wheeling agreement with MWDSC for use of capacity in MWDSC's Colorado River Aqueduct. Discussions between SDCWA and MWDSC are ongoing.

Colorado River Region options that could make water available for transfer to the South Coast Region include:

- Lining the All American Canal. Public Law 100-675 authorized the Secretary of the Interior to line the canal or recover seepage from the canal using construction funds from PVID, IID, CVWD, or MWDSC. In March 1994, USBR completed an EIS/EIR that evaluated a parallel canal alternative, several in-place lining alternatives, and a well field alternative. The EIS/EIR concluded that the preferred alternative was the construction of a concrete-lined canal parallel to 23 miles of the existing canal. The parallel canal alternative has the potential to annually conserve an estimated 67,700 af of Colorado River. Environmental documentation has been completed and a Record of Decision has been signed. At the time the EIR/EIS was completed, the well field alternative (which was less costly than constructing a now lined canal) was not pursued due to international concerns about groundwater extraction adjacent to the Mexican border. The feasibility of such groundwater extraction is presently being reevaluated.
- Lining the Remaining Section of the Coachella Canal. This project would involve lining the remaining 33.4 miles of the Coachella Canal, which loses about 32,350 af of water per year through seepage. Four alternatives that have been identified were conventional lining, underwater lining, parallel canal, and no action. It is estimated that the preferred alternative, conventional lining, would conserve 25,680 af/yr.

- On-farm Water Conservation Options. Future on-farm water conservation programs in the Colorado River Region, such as improving seasonal application efficiencies, flexible water delivery, canal lining, tailwater recovery, and constructing spill interceptor canal, and distribution system reservoirs, could attain 190 taf in depletion reductions. Improving seasonal application efficiency to 80 percent from the base of 73 percent would reduce depletions by 50 taf. The remaining options combined would achieve 140 taf in depletion reductions. Urban water agencies in the South Coast Region could fund conservation projects in the Colorado River Region, in exchange for the conserved water. However, any conservation programs that reduced the inflow of fresh water to the Salton Sea would have to be evaluated in light of the need to prepare the sea's environmental resources. Sustaining fish and wildlife resources in the sea may constrain the amount of water that could be transferred in the future.
- Interstate Water Banking. Under an existing agreement between MWDSC and the Central Arizona Water Conservation District, MWDSC can store a limited amount of Colorado River water in Arizona for future use. The Southern Nevada Water Authority is also participating in the program. The agreement stipulates that MWDSC and SNWA can store up to 300,000 af in central Arizona through the year 2000. To date, MWDSC has placed 89 taf and SNWA has placed 50 taf of water in storage for a total of 139 taf. About 90 percent of the stored water can be recovered, contingent upon the declaration of a surplus on the Colorado River by the Secretary of the Interior. When MWDSC is able to draw on this source, it can divert up to a maximum of 15,000 af in any one month. The stored water would be made available by Arizona foregoing the use of part of its normal supply from the Central Arizona Project. MWDSC plans to recover the stored water at times in the future when its Colorado River Aqueduct diversions may be limited. The Arizona legislature in its 1996 session enacted HB 2494 which establishes the Arizona Water Banking Authority. The Authority may purchase unused Colorado River water and store it in groundwater basins for future needs. Conveyance to storage areas is provided by the Central Arizona Project. The legislation provided that the Authority may

enter into agreements with California and Nevada agencies to bank water in Arizona basins, with the following limitations:

(1) Regulations governing interstate banking would need to be promulgated by the Secretary of the Interior and the Arizona Department of Water Resources

(2) ADWR finds that Interior's regulations adequately protect Arizona's rights to Colorado River water

(3) The ability to bank interstate water would be subordinate to banking of water to supply Arizona needs

(4) Interstate banking would be precluded in years when Arizona is using its full apportionment of 2.8 maf, unless surplus conditions were declared on the river system and

(5) Interstate withdrawals from the bank are limited to 100 taf per year, although there is no statutory limitation on annual deposits.

Under this legislation, future interstate banking in Arizona would have a maximum drought year yield of 100,000 af, with 50,000 af being available to California (assuming 50,000 af would be available to Nevada). However, Arizona may effectively limit withdrawals in drought years by declining to decrease its diversions of surface water that would allow recovery of the banked water.

- Land Fallowing. Land fallowing programs such as the Palo Verde test land fallowing program could be implemented to provide water for transfer to urban areas in the South Coast Region during drought periods. In 1992, MWDSC conducted a two-year land fallowing test program with Palo Verde ID. Under this program, farmers in PVID fallowed about 20,000 acres of land. The saved water, about 93,000 af per year, was stored in Lower Colorado River reservoirs for future use by MWDSC (although the water was later spilled when Colorado River flood control releases were made). MWDSC paid each farmer $1,240 per fallowed acre, making the costs of the water to MWDSC about $135/af. It is expected that similar programs could be implemented in the future by South Coast water agencies and water agencies in the Colorado River Region to provide about 100,000 af per year during drought years. Future land fallowing agreements would

need to consider the availability of storage for the transferred water — whether in Colorado River reservoirs or in groundwater basins.

- Reoperating Colorado River System Reservoirs. Member agencies represented on the Colorado River Board of California have discussed establishing new reservoir operations criteria that would benefit California while protecting the apportionments of the other basin states and satisfying Mexican treaty obligations. Such criteria would also constitute part of the package of actions for California to transition its use of river water from current levels down to 4.4 maf per year. Operation studies have been performed to evaluate specific shortage and surplus criteria for the river system, including selection of desired surplus and shortage criteria and reservoir operating elevations.

  The Colorado River has a high ratio of storage capacity to average annual runoff. Projections of consumptive use for the upper basin states suggest that those states will not attain full use of their Compact apportionments until 2060. USBR's surplus declarations to date have not adversely impacted the other states' use of their apportionments -- flood control releases were made in 1997 and are expected for 1998. The more significant impediment to implementing reoperation would be concerns of the other basin states about impacts of an extended period of reoperation on the ability to avoid future shortages.

  CRB member agencies have not yet established a position on criteria for reoperations. USBR and the other basin states would have to concur in a proposed reoperation of Colorado River reservoirs. River reoperation is deferred as a water management option, and no numerical evaluation is made in this update of the Bulletin, since there is presently no generally accepted proposal available for quantification.

- Weather Modification. One of the fundamental management issues associated with Colorado River water supplies is the apparent overstatement of the Compact apportionment (and hence ultimate basin use) relative to the river's historic hydrology. There have been a variety of proposals over the years to augment the river's base flow to help remedy this issue. For example, USBR had developed a proposed pilot program in 1993 to evaluate cloud seeding potential in the upper basin. The state of Colorado had not favored

moving ahead with this program. Weather modification has recently been raised again as part of a possible menu of options to resolve California's use in excess of the 4.4 maf basic apportionment, although no specific proposals have been made. Large-scale weather modification projects are typically difficult to implement due to institutional and third-party concerns, and can be expected to require several years of study and testing prior to being placed in operational status. Weather modification on the Colorado River is additionally complicated by interstate management issues. This option has been deferred for these reasons.

Table 7-31 is a summary of the options for the Colorado River Region that could make water available for transfer to help meet water demands in the South Coast Region. Assuming that enough water remains in the Colorado River Region to address their shortages, 252 taf and 393 taf are potentially available for transfer to the South Coast Region in average and drought years, respectively.

Table 7-31. Some Initial Elements of the Colorado River 4.4 Plan

Option	Potential Gain (taf/yr)	
	Average	Drought
Lining Portion of All American Canal	68	68
Additional Lining the Coachella Canal	26	26
On-farm Agricultural Water Conservation		
Lining canals	45	45
Flexible water delivery	30	30
Tailwater recovery	65	65
Seasonal application efficiency improvements (to 80%)	50	50
Arizona Water Banking	----	50
Land Fallowing	----	100
Total Potential Gain	284	434
Remaining in Colorado River Region	(32)	(41)
Available for Transfer to South Coast Region	252	393

Central Valley Water Transfers. More than half of California's agricultural water use is in the Central Valley, much of it is delivered by SWP and CVP conveyance facilities. The California Aqueduct could facilitate voluntary transfer of some of this water to the South Coast. It is estimated that potential future water transfers from the Central Valley to the South Coast Region could be about 200 taf. Voluntary water transfers would be developed through option agreements, storage programs, and purchases of water through the drought water bank or other similar spot markets.

MWDSC is currently banking water with **Semitropic Water Storage District** under a long-term transfer agreement to store up to 350 taf. The agreement allows MWDSC to deliver available SWP water in wetter years to Semitropic WSD for in-lieu groundwater recharge. In drought years, Semitropic would release its SWP allocation to MWDSC, and if necessary pump groundwater back into the California Aqueduct, to meet its obligations. The drought year yield could be from 32 taf to 118 taf per year.

Other water transfers proposed from the Central Valley include:

- A long-term agreement between **MWDSC and Arvin-Edison Water Storage District** to store up to 350 taf of water for MWDSC in Arvin-Edison's groundwater basin. Under the agreement, Arvin-Edison would construct a 4.3-mile pipeline connecting its system with the SWP's California Aqueduct to take a maximum of 200 taf of MWDSC's SWP supply. MWDSC would withdraw up to 75 taf in drought years.
- As specified in the Monterey Agreement, agricultural contractors will make available up to 130 taf of annual SWP entitlement for permanent transfer to urban contractors, on a voluntary basis. Berrenda-Mesa Water District has already completed the transfer of 25 af of entitlement to Mojave Water Agency. Similar permanent transfers could be negotiated in the South Coast Region. One option being proposed is the transfer of 9 taf of entitle-ment from **Wheeler Ridge-Maricopa Water Storage District to Castaic Lake Water Agency.**

Water Recycling

Since the 1970s, Southern California has been a leader in developing water recycling projects. Reclaimed water is currently used for numerous applications including groundwater

recharge, hydraulic barriers to seawater intrusion, landscape and agricultural irrigation, and direct use in industry. Currently, some 80 local recycling projects are producing about 210,000 af per year of new water supply. It is estimated that these existing projects will provide an additional 120,000 af per year of water supply by year 2020.

Approximately 50 new water recycling projects were evaluated as future water supply augmentation options for the region. Water recycling could potentially increase by 640,000 af by 2020, yielding 556,000 af of new water (3 plants, which could produce 13,000 af were deferred due to costs). The price of recycled water from these options ranges from $40/af to more than $6,000/af. This large range is due to the individual characteristics of proposed projects -- some entail major capital costs for construction of new treatment plants while others may involve only distribution systems from an existing plant. For example, projects designed for groundwater recharge are often strategically located near the treatment plant--reducing the costs for distribution. As another example, projects that are designed for landscape irrigation or direct industrial uses will generally be higher in cost because of the extensive distribution system needed for delivery.

In an effort to broaden the potential application of reclaimed water to include indirect potable use, the City of San Diego has conducted research into the advanced treatment and ultimate use of reclaimed water as a supplement to potable water supplies. This indirect potable reuse concept has been termed repurification by San Diego. The City of San Diego is currently working on a water repurification project (described in Chapter 5) that would produce about 15,000 af per year of repurified water to augment local supplies. The repurified water would be stored in the San Vicente Reservoir and blended with local runoff and imported water.

San Diego Area Water Reclamation Program

The San Diego County Water Authority and its member agencies are engaged in a long-term effort to reduce regional reliance on imported water supplies. Water reclamation is critical to the success of that effort. Two major programs underway are discussed below.

The **San Diego Area Water Reclamation Program** is a system of interconnected reclamation facilities designed to serve southern and central San Diego County. When completed, the program will serve an area of more than 700 square miles and add more than 60,000 af to the San Diego region's local water supply. Summarized below are the eight participating agencies and each agency's planned reuse. Facilities to be constructed include up to ten new or expanded water recycling plants, a state-of-the-art water repurification facility, and hundreds of miles of recycled water delivery pipeline.

Agency	Annual Reuse in Acre-Feet
City of Escondido	3,200
City of Poway	2,300
City of San Diego	26,900
City of San Diego/San Diego County Water Authority	15,000
Otay Water District	2,900
Padre Dam Municipal Water District	1,850
Sweetwater Authority	7,200
Tia Juana Valley County Water District	2,200
Total	**61,550**

Padre Dam MWD has completed construction of its treatment facility, and expects to begin delivery of recycled water in late 1997. The City of San Diego's North City water recycling plant is complete and the distribution system is currently under construction.

The **North San Diego County Area Water Recycling Project** will provide more than 15,000 af of recycled water to northern coastal and inland San Diego County. The project is a cooperative effort of the Carlsbad and Olivenhain MWDs, the Leucadia County Water District and the San Elijo JPA. When completed, the system of interconnected reclamation facilities would serve an area of more than 100 square miles, from the coastal communities of Carlsbad, Encinitas and Solana Beach inland to the San Dieguito River Valley. Facilities to be constructed include three new or expanded water recycling facilities, about 65 miles of reclaimed water delivery pipeline and associated pump stations and storage facilities, and new groundwater recharge and extraction facilities.

To evaluate and compare recycling options with other water management options, the water recycling options are grouped by cost into three groups. Group I includes those options which cost under $500 /af; Group II includes those options which cost between $500 and $1,000

/af; and Group III includes those options which cost more than $1,000 /af. The costs used to group these projects are based on the costs reported by local agencies in the 1995 WateReuse Association survey. These costs are likely to have all been calculated on the same basis by the local project sponsors. For the purposes of this Bulletin, the local agencies' costs were used to judge the order of magnitude of proposed projects' costs.

Four projects in Group III were deferred because their costs were more than $2,000 per af. Some of the larger retained projects with their associated 2020 yield include the Orange County Regional Reclamation Project (100 taf), Phase II of the West Basin Recycling Project (95 taf), and the LADWP's East Valley Water Recycling Project (40 taf). The majority of this new water will be used for landscape and groundwater recharge.

The proposed Orange County Regional Water Reclamation Project is being developed jointly by the Orange County Water District and County Sanitation Districts of Orange County. Wastewater currently discharged into the Pacific Ocean would be reclaimed to supplement the potable supplies of Orange County. The treated wastewater would be used to recharge an aquifer along the Santa Ana River, in lieu of using imported water provided by MWDSC. A plant to treat secondary effluent produced by an existing wastewater treatment plant would be constructed, along with a distribution system that would convey the recycled water to existing spreading basins. Some recycled water would also be injected into a seawater intrusion barrier in Fountain Valley. Another benefit would be that recycling the wastewater would decrease the total discharge to the ocean, which would eliminate the need for a new or expanded ocean outfall. Phase I is planned to produce 50,000 af of reclaimed water per year by 2002. Phase II and III would produce an additional 50,000 af per year by 2020. This project would reduce Orange County's dependence on imported water.

Desalination

Groundwater Recovery. Recovery of contaminated groundwater supplies is an important resource strategy for Southern California. This resource option is usually expensive -- because it involves sophisticated technologies and high energy costs. Some groundwater recovery projects serve the dual purpose of managing migration of contaminant plumes to prevent further contamination of usable aquifers.

Groundwater desalting plants currently operating include Arlington Desalter by Santa Ana Watershed Project Authority (6,700 af), Oceanside Desalter No. 1 by City of Oceanside (2,200 af), and West Basin Desalter No. 1 by West Basin MWD (1,700 af). Additional plants and plant expansions are being planned or constructed throughout the coastal areas of the Los Angeles Basin, with an estimated total installed capacity of 33,000 af per year by 2000. The estimated total net groundwater recovery potential in the South Coast is about 150,000 af.

The Santa Ana Watershed Project Authority was formed in 1972 to plan and operate facilities to protect water quality in the Santa Ana River's watershed. The Authority is a joint powers agency composed of the five larger water districts that share the watershed --Chino Basin Municipal Water District, Eastern Municipal Water District, Orange County Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District. SAWPA operates a brine disposal line which facilitates disposal of waste brine from regional desalting plants, and operates the Arlington Desalter.

Approximately 20 potential groundwater recovery projects were evaluated with a net yield of 94,000 af. Supply costs range from $300/af to $900/af. The groundwater recovery projects are grouped by cost into two groups, those projects less than $500/af and those more than $500/af.

Brackish Water Reclamation Demonstration Facility

The Port Hueneme Water Agency was formed to develop and operate a brackish water reclamation demonstration facility for its four member agencies, all of which are located along the southwestern coast of Ventura County. The BWRDF is the cornerstone of the program to improve water quality and reliability, reduce groundwater extractions and seawater intrusion in the Oxnard Plain. BWRDF will provide a full-scale demonstration of side-by-side operation of three brackish water desalination technologies (reverse osmosis, nanofiltration, and electrodialysis reversal). The feasibility of using desalination concentrate for wetlands enhancement is also being studied. Construction of the project has begun and is estimated to be complete by early 1998. The total capital costs were originally estimated at $13.8 million but are currently $2 million under budget.

Ocean Water Desalination. Ocean desalting is sometimes described as the ultimate solution to Southern California's water supply shortfall. Although there is often public support for this resource, ocean desalination is currently limited by high costs, environmental impacts of

brine disposal, and siting considerations. Based on current technology, the costs for desalination of ocean water for potable uses ranges from about $1,200 to $2,000 per af depending on the type of treatment and the distribution system that would be required to deliver the water. Although high costs may currently limit this resource, ocean desalination may prove to be an important strategy in the future. MWDSC, with joint funding from the U.S. Government and Israel Science and Technology Foundation, recently embarked on a demonstration project using a multiple-effect distillation process, as described in Chapter 5.

In the past, SDCWA has evaluated the possibility of constructing two reverse osmosis desalting facilities in conjunction with the proposed repowering of the San Diego Gas and Electric South Bay Power Plant and the Encina Power Plant. The capacity of the two plants would total 20,000 af per year. The city of Long Beach and the Central Basin MWD are also collaborating on a study of a reverse osmosis plant with 5,600 af annual capacity to be located at Southern California Edison's Alamitos power plant.

Statewide Options

Active planning for statewide water supply options is being done currently for the CALFED Bay-Delta Program and for SWP future supply. See Chapter 6 for discussion on statewide water supply augmentation options. *[The following text on SWP supplies is a placeholder for potential outcomes of CALFED process. Text will be changed as CALFED results become available.]*

CALFED Bay-Delta Program. Improving conditions in the Sacramento-San Joaquin River Delta would provide improvement to SWP supply reliability. For illustrative purposes, assuming improved Delta conditions through the implementation of CALFED alternatives, additional SWP yield to the region could be 83,000 and 88,000 af in average and drought years, respectively.

State Water Project Improvements. The Department has three programs underway to improve SWP yields to its contractors. Each program is discussed in Chapter 6. The ISDP would augment SWP supplies to the South Coast Region by 76,000 af and 54,000 af in average and drought years, respectively. The American Basin Conjunctive Use Program would provide

30,000 af to the region in drought years, and the Supplemental Water Purchase Program could provide an additional 106,000 af in drought years.

Drought Water Bank. Based on past experience with the Drought Water Bank, it is estimated that about 250,000 af of water would be purchased for allocation. Of this amount, past experience suggests that about 138,000 af would be made available to the South Coast Region.

Enlarged Shasta Lake. Enlarging Shasta Lake to 13 maf of storage would increase drought year yield by about 1.5 maf. If we assume one-third of this yield is allocated to the environment, and the remaining two-thirds is allocated among the State and federal projects, the region could potentially receive more than 300 taf per year.

Water Resources Management Plan for South Coast Region

The retained options were evaluated and scored (see Table 7A-4 in Appendix 7A) based on criteria discussed in Chapter 6. Table 7-32 shows the results of the options evaluation. In 2020, water shortages for the region are estimated to be 0.7 maf in average years, and 1.3 maf in drought years. These shortages are primarily attributed to increased urban demands and reduced Colorado River supplies.

To meet the water shortages, water agencies in the South Coast Region are planning to implement additional conservation programs, water recycling, and groundwater recovery, as well as water transfer and other water supply augmentation options. Demand management options such as urban conservation are currently an important program for all water agencies in the South Coast.

Table 7-33 summarizes the options most likely to be implemented by 2020 to meet the forecasted year shortages in the South Coast Region. Options to be implemented would include the Colorado River 4.4 Plan and a combination of local and statewide options.

Implementation of the BMPs will continue through 2020 and is reflected in the base demand levels for urban water use. Urban conservation options most likely to be implemented, based on costs and feasibility, would provide 90 taf in depletion reduction per year.

The South Coast Region will increase its reliance on water transfers as Colorado River supplies are reduced. Firm options for the first phase of the Colorado River 4.4 Plan could make available up to 252 taf in average years and 393 taf in drought years for transfer to the South

Coast Region. Additional water banking and transfer agreements as well as permanent transfer of SWP entitlement water are likely options for the South Coast Region, amounting to 9 taf and 59 taf in average and drought years respectively.

Local groundwater conjunctive use programs will likely add 200 taf of production in drought years. Water recycling will continue to be a source of water supply for Southern California. New projects costing less than $500 per af could provide an additional 186 taf per year by 2020. Groundwater recovery projects under $500 per af could provide an additional 27 taf per year.

Statewide options for the region will include a CALFED Delta fix, SWP improvements, and State drought water bank, which could provide 159 taf and 310 taf in average and drought years respectively.

[Place holder for CALFED solution and resulting SWP yield for the South Coast.]

Table 7-32. Options Ranking South Coast Region

Option	Rank	Cost per af ($)	Potential Gain (taf)	
			Avg	Drt
Conservation				
Urban				
Outdoor Water Use - New Development	M	750	140	140
Outdoor Water Use -New and Existing Development	L	*	500	500
Interior CII Water Use (2%)	M	500	20	20
Interior CII Water Use (3%)	L	700	25	25
Modify Existing Reservoirs/Operations				
Reoperate Prado Dam	H	60	5	5
Reoperate Hansen and Lopez Dams	M	*	*	*
Reoperate Santa Fe and Whittier Narrows Dams	M	*	*	*
New Reservoirs/Conveyance Facilities				
Freshwater Reservoir in Long Beach Harbor	L	800	172	-
Groundwater/Conjunctive Use				
Local Groundwater Banking/Conjunctive Use	H	350	-	200
Water Transfers/Banking/Exchange				
Colorado River Water Transfers/Interstate Banking (Colorado River 4.4 Plan)	H		252	393
MWDSC/Arvin Edison WSD Groundwater Banking	M		-	75
Castaic Lake Water Agency	H		9	9
Water Recycling				
Group 1 (Cost < $500/AF)	H	500	441	441
Group 2 (Cost $500/AF - $1,000/AF)	M	1,000	89	89
Group 3 (Cost > $1,000/AF)	M	1,500	26	26
Desalination				
Brackish Groundwater				
Group 1 (Cost < $500/AF)	H	500	27	27
Group 2 (Cost $500/AF - $1,000/AF)	M	1,000	67	67
Seawater				
Reverse Osmosis Facilities at South Bay Power Plant	L	920	5.0	5.0
Reverse Osmosis Facilities at Encina Power Plant	L	1,220	15.0	15.0
Reverse Osmosis Facilities at Alamitos Power Plant	L	1,700	5.6	5.6
Multiple-effect Distillation Process	L	<1000	85.0	85.0

Table 7-32. Continued

Statewide Options				
CALFED Bay / Delta Program	M		83.0	88.0
SWP Interim South Delta Program	M	100	76.0	54.0
SWP American Basin Conjunctive Use Program	H	175	-	30.0
SWP Supplemental Water Purchase Program	L	175	-	106.0
Drought Water Bank	H	150	-	138.0
Enlarge Shasta Lake	M		312.0	374.0

Table 7-33. Summary of Options Most Likely to be Implemented by 2020 South Coast Region

Option	*Potential Gain (taf)*	
	Avg	*Drt*
Shortage	**728**	**1,295**
Conservation	90	90
Modify Existing Reservoirs/Operations	5	5
New Reservoirs/Conveyance Facilities	-	-
Groundwater/Conjunctive Use	-	200
Water Transfers/Banking/Exchange	9	59
Recycling	186	186
Desalination	27	27
Statewide Options	159	310
Colorado River 4.4 Plan	252	393
Total Potential Gain	**728**	**1,270**
Remaining Shortage	**0**	**25**

Chapter 8. Options for Meeting Future Water Needs in Interior Regions of California

This chapter covers the interior regions of the State: the Sacramento River, San Joaquin River, and Tulare Lake hydrologic regions (Figure 8-1). These regions constitute the Central Valley, which makes up about 38 percent of the State's land area, but almost 80 percent of the State's irrigated acres.

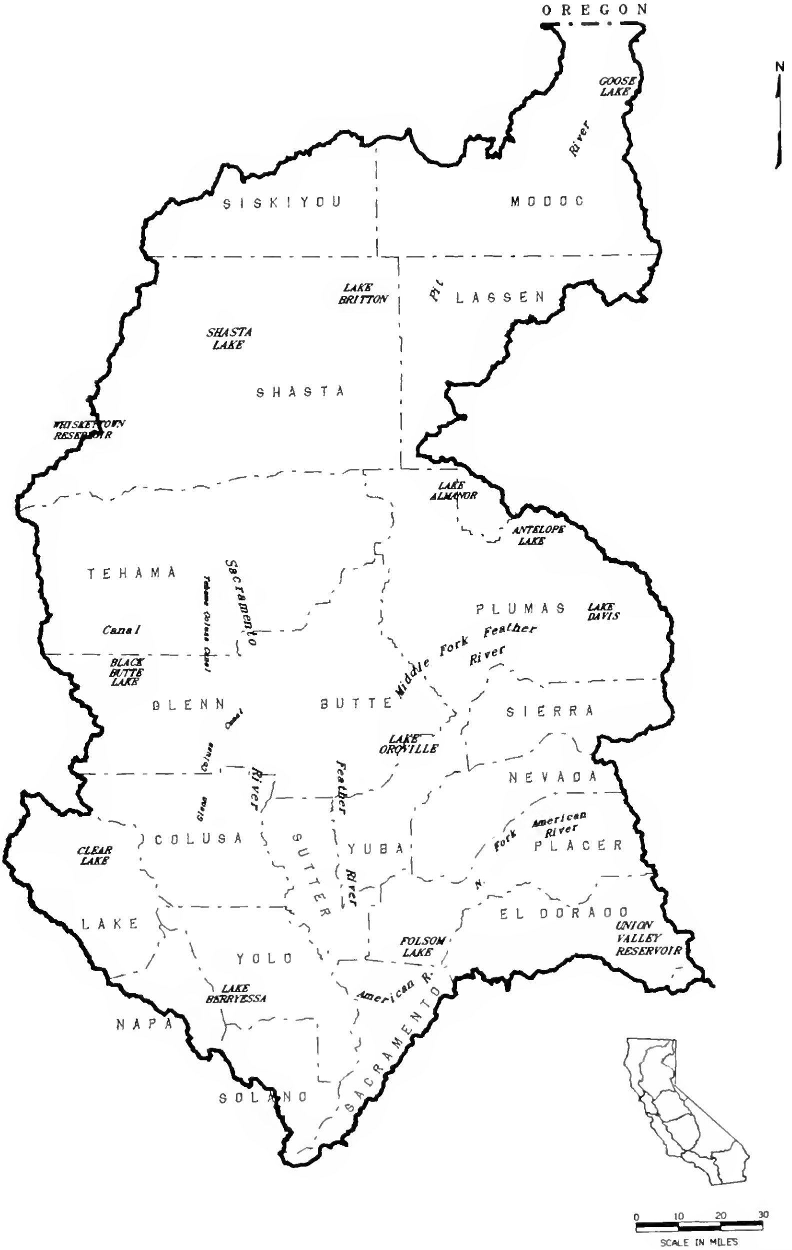
Sacramento River Hydrologic Region

Description of the Area

The Sacramento River Region contains the drainage area of the Sacramento River and its tributaries, and extends 300 miles from the Oregon border south to Collinsville in the Sacramento-San Joaquin Delta (Figure 8-2). The crest of the Sierra Nevada forms the eastern border of the Sacramento River Region, while the western side is defined by the crest of the Coast Range. The southern border includes the American River watershed and the northern Sacramento-San Joaquin Delta. The Sacramento River Region includes all or large portions of Shasta, Tehama, Glenn, Plumas, Butte, Colusa, Sutter, Yuba, Sierra, Nevada, Placer, Sacramento, El Dorado, Yolo, Solano, Lake, and Napa counties. Small areas of Modoc, Siskiyou, Lassen, Amador, and Alpine counties are also within the Sacramento River Region. The State's largest river, the Sacramento, crosses the valley, and terminates in the Sacramento-San Joaquin Delta. The Delta consists of sloughs, rivers, and islands formed by an elaborate levee system. Delta waterways are critical to transporting Sacramento River flows to the Bay Area, San Joaquin Valley, and Southern California and to sustaining fish and wildlife populations. The Sacramento Valley is comprised of eight planning subareas, all of which are hydrologically connected by the Sacramento River.

Figure 8-1. Interior Regions Hydrologic Area

Figure 8-2. Sacramento River Hydrologic Region



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The region is defined by two distinct features: (1) the foothill and mountain areas of the Sierra Nevada, Cascades, and Coast ranges, and (2) the Sacramento Valley itself. Mountain elevations range from 5,000 feet along the coast to more than 10,000 feet in the Sierra Nevada. The elevation of the valley floor gradually decreases from 500 feet in the Redding area of Shasta County to near sea level in the Sacramento-San Joaquin Delta in southern Solano and Sacramento counties.

Precipitation in the region varies substantially depending on location and elevation. In the foothill and higher mountain areas, precipitation ranges from 40 to 80 inches annually. The valley receives less rainfall, with annual rainfall for Redding and Sacramento being 35 inches and 18 inches, respectively. The mountain areas have cold, wet winters with major amounts of snow contributing runoff for summer water supply. The Sacramento Valley has mild winters and dry, hot summers.

Base year (1995) and future (2020) forecasted population for the region is provided in Table 8-1. Most of the region's population growth is expected to occur in the southern part of the region in Sacramento, Placer, El Dorado, Sutter, Yolo, and Solano counties. The Sacramento metropolitan area and surrounding communities are expected to experience significant population growth, as is the Yuba City-Marysville area in Sutter and Yuba counties.

There is extensive irrigated agriculture in the region. Rice, irrigated pasture, alfalfa, grain, fruits, nuts, and tomatoes account for about 80 percent of the irrigated crop acreage. Irrigated acreage in the region is expected to remain about the same between the 1995 base year and 2020 (see Table 8-1).

Table 8-1 . Population and Crop Acreage (thousands)

	1995	*2020*
Population	2,372,000	3,813,000
Irrigated Crop Acres (thousand acres)	2,139	2,150

Water Demands and Supplies

Water shortages are expected to occur under average and drought conditions within the region, as shown in Table 8-2. The 1995-level shortage shown in the table for average years includes groundwater overdraft. Most of the drought year water shortages are associated with agricultural water use, primarily in the valley floor area immediately north of Sacramento.

Table 8-2. Sacramento River Region Water Demand and Supply (taf)

	1995		2020	
	Average	Drought	Average	Drought
Applied Water				
Urban	766	830	1,139	1,236
Agricultural	8,065	9,054	7,939	8,822
Environmental	5,825	4,222	5,951	4,344
Total Applied Water	14,656	14,105	15,029	14,402
Supplies				
Surface Water	11,873	10,021	12,188	10,011
Groundwater	2,672	3,218	2,636	3,281
Recycled and/or Desalted	0	0	0	0
Total Supplies	14,545	13,238	14,824	13,292
Shortages	**111**	**867**	**206**	**1,109**

Excluding supplies dedicated to environmental purposes, surface water accounted for about 70 percent of the region's total average water supply in 1995. Groundwater provides the remaining supply. During drought years, additional groundwater is pumped to compensate for reduced surface water supplies.

There are 43 major reservoirs in the region, with a combined storage capacity of almost 16 maf. About half of this combined storage capacity is contained in just two of the 43 reservoirs -- the CVP's Lake Shasta and the SWP's Lake Oroville.

☞ Photo: Oroville Dam

CVP Water Supply.

Most of the water delivered by CVP facilities in the Sacramento River Region is for agricultural use. Cities that receive part of their water supply from CVP facilities include Sacramento and Redding.

The Tehama-Colusa and Corning canals, which begin at Red Bluff Diversion Dam on the Sacramento River, deliver CVP water to agricultural users and to wildlife refuges. The Tehama-Colusa Canal extends 110 miles south of RBDD, terminating in Yolo County south of Dunnigan. The Corning Canal extends 25 miles south of RBDD, terminating near Corning. Together, the canals serve about 160,000 acres of land in Glenn, Colusa, and Yolo counties. Project water and water rights settlement water users also make direct diversions from the Sacramento River.

Some of the larger water agencies receiving supplies delivered by the CVP (either project water or water rights water) are listed below. The contractual entitlement shown includes, where applicable, both project water and water rights water.

Agency	Total Contractual Entitlement (taf)
Anderson-Cottonwood ID	175.0
Glenn-Colusa ID	825.0
Natomas Central Mutual Water Company	123.0
Princeton-Codora-Glenn ID	67.8
Reclamation District 108	232.0
Reclamation District 1004	71.4
Sutter Mutual Water Company	268.0

Releases from Folsom Reservoir on the American River serve Delta and CVP export needs, as well as providing supplies to agencies in the Sacramento metropolitan area. The City of Sacramento is the largest water rights contractor on the American River, with a contract for almost 300 taf. Placer County Water Agency, one of the largest American River contractors for project water, also holds a water rights contract for 120 taf. EBMUD holds the largest contract for project water on the American River system (150 taf), which it had originally planned to take delivery of via an extension of the existing Folsom South Canal. (Use of EBMUD's American River supply is described in Chapter 7.)

CVP facilities serving communities in the foothills east of Sacramento are Jenkinson Lake (Sly Park Dam) and Sugar Pine Reservoir.

Supply from Other Federal Water Projects

Monticello Dam in Napa County impounds Putah Creek to form Lake Berryessa, the water storage facility of the USBR's Solano Project. This project provides urban and agricultural water supply to Solano County (partly in the Sacramento River region and partly in the San

Francisco Bay region) and agricultural water supply to the University of California at Davis in Yolo County. Napa County only uses about 1 percent of the supply for developments around Lake Berryessa.

SCWA is the regional water contractor for both the federal Solano Project and the SWP. Within the Sacramento River Region, SCWA member entities with contracts for Solano Project water include the City of Vacaville (which also receives SWP water and uses groundwater), Solano Irrigation District, Maine Prairie Water District, UCD, and the California Medical Facility/California State Prison-Solano. (The cities of Fairfield, Vallejo, and Suisun City in the San Francisco Bay Region also have SCWA contracts for Solano Project water, as discussed in Chapter 7.) SID contracts for 141,000 af of Solano Project water from SCWA and delivers it to agricultural users in Solano County.

☞Photo: Monticello Dam

SWP Water Supply

Lake Davis, Frenchman Lake, and Antelope Lake are located on Feather River tributaries in Plumas County and used primarily for recreation, provide water supply to Portola and to local agencies having water rights agreements with the Department. Lake Oroville and Thermalito Afterbay also provide supply within the region. Local agencies that receive water rights water delivered at Thermalito Afterbay include Western Canal Water District, Richvale Irrigation District, Biggs-West Gridley Water District, Butte Water District, and Sutter Extension Water District. Agencies in the region holding long-term contracts for SWP supply are Yuba City, Butte County, Solano County Water Agency, and Plumas County Flood Control and Water Conservation District. In 1995, the cumulative SWP deliveries to these agencies were 209,528 af. SCWA is served by the SWP's North Bay Aqueduct, which diverts water from the Delta.

Local Surface Water Supply

Water stored and released from Clear Lake and Indian Valley Reservoir into Cache Creek is diverted by the Yolo County Flood Control and Water Conservation District for irrigation in Yolo County. Since 1950, the district has diverted an average of 130,000 af annually at the Capay Dam Diversion on lower Cache Creek. No water supply from these sources was available during the 1977 and 1990 drought years.

In Sutter County, and in the western portion of Placer County, agricultural water is supplied by South Sutter Water District from Camp Far West Reservoir on the lower Bear River. SSWD also purchases surface water from Nevada Irrigation District to supplement irrigators' groundwater supplies. NID's supplies come from its reservoirs on the Bear River system. Yuba River supplies have been developed by Yuba County Water Agency, which owns the 970 taf New Bullards Bar Reservior, the river's largest reservoir.

The Sacramento metropolitan area, served by over 20 water purveyors, is the largest urban area in the Sacramento Region and is also the largest urban user of surface water. Within Sacramento County, the City of Sacramento relies primarily on surface water; water purveyors in unincorporated areas use both surface water and groundwater. The City of Sacramento diverts its CVP water rights water from the American River at H Street, and also diverts from the confluence of American and Sacramento Rivers. Approximately 80 to 90 percent of the city's water supply comes from surface diversions, with the Fairburn WTP providing more than 50 percent of the surface water supply (water quality in the American River is better than that in the Sacramento). The City of Folsom and Folsom Prison get surface water from Folsom Lake.

Groundwater Supply

Most groundwater used in the region comes from alluvial aquifers on the Sacramento Valley floor. The Sacramento Valley is a major groundwater basin, with an estimated 114 maf of water in storage (at depths of up to 600 feet). (Only a portion of this amount is available for extraction.) Well yields in alluvial areas vary significantly depending on location, and pumping yields range from 100 to 4,000 gpm. Foothill communities that use groundwater generally rely on fractured rock sources that have yields lower than those found in valley floor alluvium.

Redding supplements its CVP surface water supply with self-supplied groundwater. Smaller communities in the northern and central Sacramento Valley, such as Anderson, Red Bluff, Marysville, Olivehurst, Wheatland, Willows, Corning, and Williams, rely almost entirely on groundwater and have adequate supplies to meet local demands for the foreseeable future. Woodland, Davis, and Dixon are completely dependent on groundwater. UCD urban demands and some agricultural demands are served from groundwater. Most residents in unincorporated areas rely entirely on groundwater.

In the Sacramento metropolitan area, groundwater is supplied by the cities of Sacramento and Galt, Sacramento County, and local water agencies. There are two areas of overdraft in Sacramento County aquifers, one near McClellan Air Force Base and the other in the Elk Grove area.

Local Water Resources Management Issues

Sierra Nevada Foothills

Urbanization of productive agricultural lands in the Central Valley is a land use issue currently attracting significant public attention. One alternative to urban development on valley floor agricultural lands is increasing development on non-arable lands in the adjoining Sierra Nevada foothills. However, the foothill areas also have land use and water supply concerns associated with development pressure, particularly for communities within commuting distance of the valley's major population centers.

Historically, the rural foothill counties have had economies based on natural resource development (e.g., ranching and logging). Tourism is becoming increasingly important. Although individual foothill communities have experienced relatively high growth rates, the region's overall population is small, and future development is constrained by the high percentage of federal lands managed by the USFS and the National Park Service.

Although there has been extensive development of large-scale water projects in the Sierra foothills, that development serves downstream urban and agricultural water users. The foothills' local water supply infrastructure is limited, with some water users still being served by open ditch and flume systems that date back to gold rush-era mining operations. The area's development pattern of small, geographically dispersed population centers and its lack of a financial base for major capital improvement projects constrains the ability to interconnect individual water systems and to develop centralized sources of water supplies, limiting options for water transfers. The area's small population translates into high per capita costs for water supply improvements. Many individual residences and subdivision developments rely on self-supplied groundwater, from wells tapping fractured rock aquifers. Groundwater resources from fractured rock sources are highly variable in terms of water quantity and quality, and are an uncertain source for large-scale residential development.

Management of existing water supplies, especially in terms of increasingly stringent drinking water quality requirements, is a challenge for some foothill water systems. As with water supply, interconnections for water treatment purposes are challenged by the geographic and topographic constraints of the foothill areas. System consolidations are also complicated by the relatively large percentage of the foothill population living in unincorporated areas, and the correspondingly high number of small, independent water systems. Historically, one source of localized water quality problems has stemmed from isolated developments that rely on groundwater as a source of supply and also use septic tank systems for waste disposal. Some of these systems eventually experience groundwater contamination problems, leading to the need to provide a new water supply or to connect the development to a regional sewage system, if one exists.

Through 2020, there are no anticipated water shortages in average water years in the Sierra foothill area above the Central Valley floor (an area including part of the Cascade Range tributary to the Sacramento River, and stretching from Modoc County on the north to Kern County on the south). Drought year shortages in 2020 are forecast to be 220,000 af, over 60 percent of which is associated with agricultural water use. The area's limited payment capacity and its need for drought year supplies suggests that participation in regional water supply projects with larger water agencies would be a probable option. Although local agencies have evaluated a number of new reservoir projects in the past (see water management options section), these projects have not gone forward.

Colusa Basin Drainage District

In 1995, the Colusa Basin Drainage District finalized a study that identified projects to meet six objectives: (1) protect against flood and drainage; (2) preserve and enhance agricultural production; (3) capture surface or storm water for conservation, conjunctive use, and increased water supplies; (4) facilitate groundwater recharge to help reduce overdraft and land subsidence; (5) improve and enhance wetland and riparian habitats; and (6) improve water quality. Some projects subsequently selected by the district for feasibility and preliminary design studies have potential water supply benefits -- two onstream reservoirs and one groundwater recharge project. These projects are described in the discussion of water management options. Much of the present supply for agricultural water users in the Colusa Basin comes from return flow contracts

for CVP water. These irrigation return flows have become an increasingly unreliable supply for Colusa Basin Drain diverters as USBR requires stricter water conservation measures of its upstream water contractors.

Groundwater Management Actions

The Sierra Valley Groundwater Management District adopted an ordinance in 1980 to limit the amount of groundwater extraction in Sierra Valley. A subsequent legal challenge led to a repeal of the ordinance by the SVGMD. The district has now focused its efforts on monitoring the basin's groundwater levels and requesting voluntary reductions in extractions. The Tehama County Board of Supervisors in 1992 amended the Tehama County Code by enacting urgency ordinances to prohibit groundwater mining within the County and extraction of groundwater for export without a permit granted by the Board. In 1996, the Tehama County Flood Control and Water Conservation District adopted a resolution of intent to develop a countywide AB 3030 plan and prepared a draft plan to serve as the basis for developing agreements with local pumpers.

Butte County has enacted two ordinances to regulate groundwater extraction. The purpose of one ordinance is to "attempt to reduce potential well interference problems to existing wells and potential adverse impacts to the environment which could be caused by the construction of new wells or the repair or deepening of existing wells. . ." The ordinance sets pumping capacity limits of not greater than 50 gallons per minute per acre to reasonably serve the overlying land, including contiguous parcels of land under the same ownership. In addition, the ordinance establishes well spacing requirements based on the engineered pumping capacity of the well. Well spacing requirements range from 450 feet for a 1,000 gpm well to 2,600 feet for a 5,000 gpm well. The ordinance also increased the well sealing to 50 feet for all wells to minimize the risk of shallow water contamination into a deep aquifer.

The Tehama County ordinance, approved by the voters in 1996, regulates exportation of groundwater out of the county and substitution of groundwater for surface water when surface water is sold. The ordinance charges the Butte County Water Commission with issuing permits for export of groundwater, or for substitution of groundwater for surface water when surface water is sold. The ordinance requires the Butte Basin Water Users Association to analyze and report safe yield of each groundwater subbasin annually.

Glenn County enacted a groundwater ordinance in 1977. This ordinance requires a permit to export groundwater outside the county. A permit can only be issued if it is found that export will not result in overdraft, adverse impacts to water levels, and seawater intrusion. The Board of Supervisors may impose conditions for the public health, safety, and welfare of the people of the county. Glenn County is preparing a groundwater management plan (AB 3030) in collaboration with the local Resource Conservation District, Farm Bureau, and water agencies. The plan is expected to be complete in mid-1998.

Sacramento Water Forum

The Sacramento Water Forum was formed in 1993 to discuss ways to provide a water supply for the region's planned development while preserving the fishery, wildlife, recreational, and aesthetic values of the lower American River. SWF membership includes the cities of Sacramento, Galt, and Folsom; County of Sacramento; twenty-plus water agencies; several environmental groups; and representatives from the business community and other community groups. In 1995 the SWF began meeting jointly with water managers in Placer and El Dorado counties.

Working together as the Foothill-Forum Water Group, they developed proposed draft recommendations for lower American River actions, releasing a *Draft Recommendations for a Water Forum Agreement* in 1997. The proposed solution includes an integrated package of the following seven actions:

- Increase surface water diversions
- Alternative water supplies to meet customers' needs while reducing diversion impacts on the Lower American River in drier years
- An improved pattern of fishery flow releases from Folsom Reservoir
- Lower American River habitat mitigation
- Water conservation
- Groundwater management
- Water Forum successor effort

Generally, foothill water interests would increase their diversions from the American River in average and wet years, and decrease those diversions in drier and driest years. Placer County Water Agency would be providing excess water from non-American River sources to

many of the participating water agencies during drier and driest years to help make up the decreased American River diversions in those years. PCWA's participation in many of these specific agreements is dependent upon SWRCB approval for changes to conditions of its existing water rights. The proposal calls for conjunctively managing surface and groundwater supplies, to help manage declining groundwater levels in parts of Sacramento County, and mandates water conservation measures.

An example of the regional cooperation that the SWF hopes to foster is a joint pipeline project being carried out by two CVP contractors -- San Juan Water District and Sacramento County Water Agency. SJWD has completed the first two phases of a joint pipeline project which will provide surface water to northern Sacramento County water purveyors. Phase III would extend the pipeline to the Rio Linda WD, McClellan AFB, and the westerly Citizens Utilities service areas. By providing surface water supplies, the wholesale purveyors along the pipeline route can reduce their dependence on groundwater, thereby allowing the groundwater basin to recharge.

One element of the SWF's draft proposal is a recommended joint City of Sacramento/EBMUD diversion at the city's existing water treatment plant. Instead of taking its American River CVP supply by extending the existing Folsom South Canal, EBMUD would divert at the City's plant farther downstream and construct a pipeline to its service area. This proposal is intended to maintain high flows in the lower American River for fishery purposes. As described in Chapter 7, EBMUD is evaluating that alternative, as well as a Folsom South Canal extension, in a draft EIR/EIS released in November 1997.

Foothill Area Water Supply from American River Basin

El Dorado County water agencies have made several attempts to develop local supplies in the American River Basin, in anticipation of their service areas' future water needs. Originally, USBR's multipurpose Auburn Dam was to provide local supply. When Auburn Dam did not go forward, El Dorado Irrigation District and El Dorado County Water Agency proposed a joint water supply and hydropower project in the late 1970s. The South Fork American River project would have included a large dam at the Alder Creek site, a Texas Hill reservoir on Weber Creek, two diversion dams, and several powerplants. When the SOFAR project did not prove to be financially feasible, a small Alder Creek Reservoir project with a storage capacity of 31 taf was

investigated. In 1993, EDCWA released a final EIR for water supply development in EID's service area. Alternatives included a 15,000 af/yr CVP water service contract for deliveries from Folsom Reservoir (authorized in PL 101-514), the El Dorado project, the Texas Hill reservior, small Alder reservoir, and White Rock project. The preferred alternative was identified as a combination of the water service contract, the El Dorado project, and the White Rock project.

EDCWA subsequently executed the CVP water service contract and EID sought to implement the El Dorado project, a proposal to acquire rights to consumptively use water that had been developed by PG&E for hydropower generation. In 1996, SWRCB's Decision 1635 approved EID's water rights filing for 17 taf of consumptive use from PG&E's Caples, Aloha, and Silver Lakes on the Silver Fork of the American River and its tributaries, based in part on a PG&E agreement to sell facilities of the hydropower project to EID. Several other water right holders petitioned SWRCB to reconsider its decision. EID and PG&E subsequently went to litigation over sale of the facilities, and EID's EIR for the El Dorado project was found inadequate by a Superior Court judge. The project is currently on hold.

EID's White Rock project is a diversion and conveyance project that would build about 4.5 miles of pipeline to connect an EID treatment plant with an existing SMUD penstock. The project would not provide additional water supply.

Alternatives to meet future water needs for Georgetown Divide PUD were identified in a 1992 planning report that examined a potential reservoir project on Canyon Creek. The reservoir project was found not to be affordable for the service area. The most promising potential project was a diversion and conveyance of Rubicon River water to GDPUD's service area. This alternative would entail acquisition of water rights and negotiation of an agreement with the Sacramento Municipal Utility District to mitigate the project's impacts on SMUD's hydropower generation.

In the 1990s, USBR conducted its American River Water Resources Investigation to evaluate local area water supply options that would make up the water supply that was to have been provided by Auburn Dam. The AWRI study proposed two major alternatives for meeting municipal and agricultural water supply needs in portions of Sacramento, San Joaquin, El Dorado, Placer, and Sutter counties through 2030 -- a conjunctive use alternative and an Auburn Dam alternative. (The Auburn Dam alternative also entailed a conjunctive use component.)

Three alternative Auburn Reservoir sizes were studied: 430,000 af, 900,000 af, and 1,200,000 af. A prepublication draft of the final EIR/EIS for this investigation was released in January 1997. However, study participants have now proposed a third alternative consisting of common elements of the two other alternatives.

Sacramento River Flood Control Project

After a series of major floods in the late 1800s and early 1900s in the Sacramento Valley, congressional authority for the Sacramento River Flood Control Project was granted in 1917. The project was built with the help of local, State, and federal funding. The project includes levees, overflow weirs, bypass channels, and channel enlargements. Overflow weirs allow excess water in the main river channel to flow into bypasses in the Sutter Basin and Yolo Basin. This system is designed to carry 600,000 cfs of flood water past Sacramento -- 110,000 cfs in the Sacramento River itself through downtown Sacramento and West Sacramento, and nearly 500,000 cfs in the Yolo Bypass. The system has worked exceedingly well over the years. However, many miles of levees sustained considerable erosion damage during the January 1997 flood.

The capacity of the SRFCP was increased with the construction of Shasta Dam in 1945 and Folsom Dam in 1956. The Feather and Yuba River systems did not share in the SRFCP's flood control benefits; however, supplemental protection was provided by the construction of Oroville Dam on the Feather River in 1968 and New Bullards Bar Dam on the Yuba River in 1970. These are large multi-purpose reservoirs in which flood control functions share space with water supply functions.

American River Flood Protection

After the floods of February 1986, USACE reanalyzed American River basin hydrology and concluded that Folsom Dam offered about a 65-year level of flood protection to the downstream Sacramento area, significantly less than the 250-year protection estimated in the late 1940s when Folsom Dam was designed. Local, State, and federal agencies worked together to identify ways to mitigate the American River basin's flood problems. In December 1991, the American River Watershed Investigation Feasibility Report and EIR/EIS were completed and identified alternative measures. The report recommended a flood control detention dam near Auburn. In 1992, Congress directed USACE to do specific follow-up flood control studies. Three main alternatives were evaluated. Two of the alternatives would increase the flood control reservation in Folsom, modify the spillway and outlet works, and improve downstream levees. The third alternative would construct a detention dam at Auburn, with downstream levee improvements. USACE studies identified the detention dam as the plan that maximized the net national economic benefit. The State Reclamation Board endorsed the detention dam as the preferred alternative in 1995. In 1996, the USACE recommended deferring a decision on long-

term solutions and to proceed with the levee improvements common to the alternatives. Congress authorized $57 million in 1996 for construction of the levee improvements.

The Central Valley's January 1997 flood disaster triggered another examination of American River hydrology. Based on that hydrologic review, the 1986 and 1997 floods are now considered to be about 65-year events. The 1997 flooding also triggered the payback provisions of the Sacramento Area Flood Control Agency's agreement with USBR, under which USBR sets aside up to 270 taf of additional winter flood control space in Folsom. (This additional flood control space in the reservoir raises Sacramento's level of protection to about an 85-year event.) Because the January 1997 flood event was followed by an unusually dry spring, the re-operation of Folsom Dam to provide additional flood control resulted in a loss of supply to USBR. SAFCA arranged for the purchase of 100 taf to offset the loss of supply -- 50 taf from YCWA, 35 taf from PCWA, and 15 taf from GCID (through groundwater substitution). SAFCA paid for 25 percent of the costs; the federal government paid for the remainder.

☞Photo: American River high water at H Street Bridge

Yuba River Flood Protection

The Marysville - Yuba City area, located at the confluence of the Feather and Yuba rivers, has been threatened by flooding from levee breaks. New Bullards Bar Reservoir on the Yuba River, the only Yuba River basin reservoir with dedicated flood control storage, can regulate less than half the river's runoff. Peak flows in the Feather River are greatly reduced by Lake Oroville, and, if releases are timed, Feather River flows can be reduced to help pass flood peaks on the Yuba River. The middle and south forks of the Yuba River and Deer Creek have no dedicated flood storage. USACE and YCWA have studied flood control features to reduce flooding on the Yuba River and downstream on the Feather and Sacramento rivers. A large reservoir site (the old Marysville project, or similar dams near the Yuba River Narrows) was studied by USACE, YCWA, the Department, and others at various times in the 1950s through the 1980s. Smaller reservoir projects have been studied in this same general area, including a potential project by YCWA known as Parks Bar. As described in the water management options section, YCWA is also evaluating an offstream site known as Waldo Reservoir. Waldo Reservoir, which is being evaluated for water supply potential as well as for flood control, could

provide conservation storage to replace a similar amount of conservation storage set aside at Oroville or New Bullards Bar for additional flood control needs.

Sacramento River Mainstem Flood Protection and Water Supply

Enlargement of Shasta Reservoir has been examined in the past by USBR and DWR as a statewide water supply option. Reservoir enlargement would also provide additional flood protection on the Sacramento River mainstem. When the project was last reviewed in the 1980s (at a very cursory appraisal level of detail), its costs were quite high, reflecting the project's magnitude (up to 10 maf of additional storage capacity). Railroad and highway relocations were a substantial cost item. In the wake of the January 1997 flooding, there is renewed interest in reexamining Shasta's enlargement, and in considering a range of potential reservoir sizes. Enlarging Shasta as a statewide water management option could provide the opportunity for local agencies in the region to participate in the project, especially smaller agencies that lack the resources to develop new local projects themselves.

Reliability of Facilities in the Sierra Foothills

Conveyance system reliability is a concern in foothill areas of the region where sources of surface supply are often limited. Conveyance facilities are vulnerable to localized flooding and earthquake or landslide damage. After the 1997 floods, a landslide destroyed a 30-foot section of Georgetown's canal which supplies water to 9,000 customers in six towns in rural El Dorado County. Nearby, EID also lost use of its flume from the forebay on the American River due to another landslide. The district is currently developing alternatives to repair or replace the flume. The communities of Cohasset and Forest Ranch in Butte County are considering building a pipeline to convey part of Butte County's SWP supply to urban users in this area east of Chico. During extended drought conditions, some of the wells now serving the area have gone dry, and water has had to be brought in by truck.

Also in Butte County, the Department's Division of Safety of Dams recently reduced the allowable operating capacity of Paradise Irrigation District's Magalia Reservior because of seismic safety concerns. The 2,900 af capacity reservoir is impounded by a hydraulic fill dam built in 1918. Restoring the 1,500 af reduction in storage capacity is estimated to cost about $10 million.

Putah Creek Adjudication

USBR stores and diverts water from Putah Creek through its Solano Project. Solano Project operations are subject to a condition which reserves water for users upstream of Monticello Dam in Lake Berryessa. In 1990, two project water users (SID and SCWA) commenced an action in Solano County Superior Court to determine all rights to the use of water from Putah Creek and its tributaries. Among other issues, the action required a determination of how rights can be exercised among USBR and upstream water users. An agreement was negotiated among SID, SCWA, USBR, and upstream water users. In 1996, the SWRCB adopted an order (WR 96-2) amending appropriative water rights in the upper Putah Creek watershed to be consistent with the negotiated agreement.

Fish Passage at Red Bluff Diversion Dam

USBR completed Red Bluff Diversion Dam in 1964. The dam diverts Sacramento River water into the Tehama-Colusa and Corning canals to supply irrigation and refuge water needs. During the 1970s and 1980s, large fishery declines in the upper river were partly attributed to the dam and the canal intake screens. The dam delayed the upstream passage of migrating adult salmon and steelhead and disoriented downstream migrating juveniles, which made them vulnerable to predation by squawfish. The original fish screens also permitted passage of many juvenile fish into the canals.

In 1986, USBR began raising the gates of the dam between December and March to allow fish passage. The gates-up period has been expanded in response to ESA requirements for winter-run chinook salmon; the current objective is for eight consecutive months (September 15 to May 15) each year to allow unimpeded fish passage during the migration season. In 1991, new drum fish screens and bypasses were installed at the canal headworks and are now operating successfully. As discussed in Chapter 2, USBR and USFWS are operating a research pumping plant at the dam, and evaluating the effects of different pump types on fish. The plant supplies water to the canals during the eight months when the dam gates are raised.

☞Photo: RBDD

Glenn-Colusa Irrigation District Fish Screen

The 175,000 acre Glenn-Colusa Irrigation District has the largest diversion on the Sacramento River north of the Delta (maximum diversion capacity of 3,000 cfs), which it takes

under a pre-1914 appropriative water right. GCID may divert up to 825,000 af from April through October for irrigation supply. (Rice is the dominant crop in GCOD.) GCID exercises its rights to divert via a USBR water rights settlement contract. GCID also supplies water to three national wildlife refuges -- Sacramento, Delevan, and Colusa.

GCID's pumping plant is located on a river side channel, upstream of Hamilton City, near Chico. DFG constructed a 40-drum rotary screen fish barrier at the plant's intake in 1972, to prevent entrainment of juvenile fish. This screen system did not perform as designed, resulting in an unacceptably high rate of juvenile fish mortality. In 1991, ESA listing of the winter run chinook salmon resulted in a court order to GCID to restrict its pumping and to install a new fish screen. CVPIA included remediation of fish passage problems at the plant in the environmental restoration actions that USBR and USFWS were to implement. In 1993, GCID completed an interim flat plate screen while a permanent solution was being developed. An environmental document identifying a preferred fish passage alternative -- a new flat plate screen with a gradient control facility in the main channel of the Sacramento River -- was released in 1997. Construction is scheduled to begin in 1998.

Fish and Wildlife Restoration Activities in the Sacramento Valley

There are many ongoing fishery restoration actions or projects in the Sacramento Valley. Some of the larger projects are described below, in order from north to south.

Mill and Deer creeks support spring run chinook salmon, a candidate species under the California ESA. In 1995 state legislation gave the creeks protection from future water development (similar to protection provided by the California Wild and Scenic Rivers Act), by restricting construction of new dams, reservoirs, diversions or other water impoundments. The Mill and Deer Creek Watershed Conservancies were also formed in 1995. The conservancies have initiated a watershed planning and management process with the assistance of EPA grant funding. Members cooperate in gathering necessary data to preserve anadromous fisheries habitat while maintaining economically productive land uses. The Department has participated with Mill Creek landowners in an experimental project which constructs wells to supplement irrigation supplies during spring fish migration periods. A similar project is being negotiated with Deer Creek water users.

Big Chico Creek supports a remnant population of spring run salmon, as well as some fall run salmon. In 1996, M&T Ranch and Llano Seco Ranch pumps were relocated from the creek to the Sacramento River to eliminate a fish hazard at the mouth of creek which had impeded passage of young out-migrating fish. Other fishery issues, such as modification of small temporary dams and a permanent fish ladder, revegetation of Lindo Channel, and development of a fishery management plan, are being investigated.

☞Photo: Western Canal fish restoration project

Butte Creek, a Sacramento Valley tributary, is presently receiving intensive fishery restoration attention is Butte Creek. This creek has a large spring run salmon population and also supports a small fall salmon run. Recent fishery restoration efforts on Butte Creek began in 1995 when M&T Chico Ranch and DFG agreed to install a new fish ladder at the Parrott Phelen Dam and new screened diversions. M&T Ranch also dedicated 40 cfs of instream flow for fishery needs on Butte Creek. Western Canal Water District and private landowners have agreed to remove the Point Four Diversion Dam on Butte Creek near Nelson. In 1997, WCWD began construction of a siphon under Butte Creek which will allow removal of its main dam and two smaller downstream dams. This siphon will separate the canal system from Butte Creek and eliminate fish losses caused by the diversion. This $8 million project is scheduled for completion in 1998. In 1997, work began on a new fish ladder and screen at the second largest downstream diversion dam. Adams Dam and Gorrill Dam are also scheduled for upgraded ladders and screens in 1998. When completed, four diversion dams will have been removed. Four others will be refurbished to improve fish passage. Other diversion dams in the nearby Butte Slough and Sutter Bypass areas are being evaluated by the Nature Conservancy and California Waterfowl Association for fish passage improvements.

☞Photo: Parrott Phelan Dam

Other Sacramento River water users are moving forward on fish screen projects. The Pelger Mutual Water Company and Maxwell Irrigation District completed screens in 1995. Princeton-Codora-Glenn Irrigation District and Provident Irrigation District started construction on a new screened pumping plant on the Sacramento River which is expected to be operational in 1998. Reclamation District 108 started building its new fish screen at its Wilkins Slough Diversion on the Sacramento River in 1997. The new screen is expected to be operational by the

1999 irrigation season. Reclamation District 1004 is completing final design and will begin construction on its new fish screen and pumping facility in 1998. Natomas Central Mutual Water Company will soon initiate feasibility studies for a large screening project on the lower Sacramento River. Glenn-Colusa Irrigation District is moving forward on the environmental review of a screening project. On the Yuba River, Browns Valley Irrigation District will install a fish screen in 1998.

Clear Creek near Redding is another location in the Sacramento River Basin where fishery restoration work has been performed. Additional work would include a new fish passage around McCormick-Saeltzer Dam, gravel placement, and sediment control. Much of the riparian land along Clear Creek below Whiskeytown Reservoir has been acquired by BLM and by the Wildlife Conservation Board.

Other Sacramento River Region streams with environmental restoration studies underway are Battle Creek and Lower Stoney Creek. Potential restoration work at Battle Creek includes studies of fish passage, instream flows, screened diversions, and hatchery modernization. Glenn County is in the process of seeking funding and planning for a Lower Stony Creek watershed restoration program.

Water Needs for Rice Field Flooding

Sacramento Valley rice fields provide overwintering area for about one-third of all migrating waterfowl in California. Historically, many farmers in the Sacramento Valley have flooded harvested rice fields to attract waterfowl for hunting. More recently, thousands of acres of additional rice lands are being flooded for rice straw decomposition due to burning restrictions imposed by the Rice Straw Burning Act of 1991 (as amended in 1997). Seasonal flooding in response to this act is creating more artificial wetlands for migrating and overwintering waterfowl.

Flooding of harvested rice lands for rice straw decomposition influences the timing of surface water diversions, placing additional demands during fall and winter months. Most flooding begins in mid-October and continues into November. Flooded conditions are usually maintained through March. In 1994-95, the Department conducted a study in three Sacramento Valley planning subareas (Northwest Valley, Central Basin West, and Central Basin East) to evaluate fall and winter water use. The study area included approximately 123,000 acres of

flooded rice land. The estimated applied water requirements for flooded rice lands was 260 taf; the estimated ETAW was 107 taf.

Presently, flooding harvested rice fields for rice straw decomposition is the most common cultural practice used in lieu of burning. However, rice growers are investigating alternative methods for rice straw removal. For example, rice straw is being considered on an experimental basis for a variety of commercial and industrial uses such as plywood, press board and fruit packing boxes, erosion control, paper pulp, and fuel. If any of these methods are proven to be an economically viable alternative to rice straw disposal by decomposition, water demands could decrease.

Water Management Options for the Sacramento River Region

Water management options in the Sacramento River Region have been extensively investigated by federal, State and local governments over the last 60 years. Many of the federal and State options were explored for their potential to augment CVP or SWP water supplies. Some projects, once studied as statewide options, are now being considered for meeting future local water supply and flood control needs in the Sacramento River Region. However, some large on and offstream reservoirs are beyond the development capacity of local water agencies, and are considered potential statewide options. These statewide projects are presented in Chapter 6.

Table 8-3 shows an initial list of water management options for the region, and those options that were deferred, and the reasons for their deferral. Options were deferred from detailed evaluation because of lack of project data, undetermined or low yields, legal and institutional constraints, project economics, and environmental concerns. After initial evaluation, 16 local options were retained for further evaluation (Appendix 8A Table 8A-1). The results are shown in Table 8-4.

Table 8-3. Comprehensive List of Options Sacramento River Region

Category	Option	Retain or Defer	Reason for Deferral
	Wambo Bar Reservoir (Yuba County)	Defer	Undetermined yields; primarily hydropower project.
	Marysville Dam Flood Control Project (Yuba County)	Defer	Undetermined yields; primarily flood contol project.
	Blue Ridge Reservoir (Yolo County)	Retain	
	Thurston Lake Pump-Storage Project	Retain	
	Parks Bar Reservoir (Yuba County)	Retain	
	Waldo Reservoir (Yuba County)	Retain	
	Whiterock	Defer	Would not provide additional water supply.
	Texas Hill	Retain	
	Small Alder	Retain	
	Canyon Creek Dam (GDPUD)	Defer	Excessive costs.
	GDPUD Diversion from Middle Fork of American River	Retain	
Groundwater/Conjunctive Use			
	New Wells (Redding, Butte, and Colusa basins)	Retain	
	USBR/Ducks Unlimited Conjunctive Use	Retain	
	Big Valley Conjunctive Use(Lake County)	Retain	
	Orland-Artois Groundwater Recharge Basin	Defer	Lack of project data, no yields determined.
	Oro-Chico Conduit	Defer	High capital cost, undetermined yields, basin recharge adequate at this time.
	Adobe Creek Detention Structure (Lake County)	Defer	Negative environmental impacts.
Water Transfers/Banking/Exchange			
	Anderson-Cottonwood Irrigation District	Defer	Institutional and legal constraints.
	Bella Vista Water District	Defer	Institutional and legal constraints.
	GCID In-Basin Annual Water Transfer Program	Defer	Institutional and legal constraints.
Conservation			
Urban			
	Outdoor Water Use to 0.8 ET_o	Defer	No substantial depletion reductions attainable.
	Residential Indoor Water Use	Defer	No substantial depletion reductions attainable.
	Interior CII Water Use	Defer	No substantial depletion reductions attainable.
	Distribution System Losses	Defer	No substantial depletion reductions attainable.
Agricultural			
	Seasonal Application Efficiency Improvements	Defer	No substantial depletion reductions attainable.
	Flexible Water Delivery	Defer	No substantial depletion reductions attainable.
	Canal Lining and Piping	Defer	No substantial depletion reductions attainable.
	Tailwater Recovery	Defer	No substantial depletion reductions attainable.
Modify Existing Reservoirs/Operations			
	Raise Camp Far West Reservoir	Defer	Economics.
	Lower Bear River Expansion Project	Defer	Uncertainties with water rights issues.
	Reoperation of Caples, Aloha, and Silver reservoirs	Retain	

**Table 8-3. Comprehensive List of Options
Sacramento River Region**

Category	Option	Retain or Defer	Reason for Deferral
New Reservoirs/Conveyance Facilities			
	Wilson Creek Reservoir (Glenn County)	Defer	Undetermined yields; primarily flood control project.
	Golden Gate Reservoir (Funks Creek, Colusa County)	Defer	Undetermined yields; primarily flood control project.
	Dry Creek Reservoir (Lake County)	Retain	
	Bear Creek Reservoir (Colusa County)	Retain	
	Wilson Valley Reservoir (Lake County)	Retain	
	Garden Bar Reservoir (Placer, Nevada counties)	Defer	Economics.
	Long Bar Reservoir (Yuba County)	Defer	Undetermined yields; primarily hydropower project.
Water Recycling			
	---	Defer	By definition in this Bulletin, does not generate new water.
Desalination			
Brackish Groundwater			
	---	---	---
Seawater			
	---	---	---
Other Local Options			
	New Surface Water Diversion from Sacramento River and Cache Creek by YCFC&WCD	Retain	
	New Surface Water Diversion from Sacramento River by cities of Benicia, Fairfield, and Vallejo (Vacaville)	Retain	
Statewide Options			
	SWP American Basin Conjunctive Use Program	Retain	
	Auburn Dam	Retain	
	CVPIA Water Acquisition Program	Retain	

Water Conservation

Urban. Urban conservation options were deferred from detailed evaluation because there is little potential to create new water (reduce depletions) in the Sacramento River Region from these options.

Agricultural. Agricultural conservation options were deferred for the same reason within this region. Water that is not consumed by evapotranspiration is recoverable either as surface or groundwater for reuse downstream.

Modify Existing Reservoirs/Operations

Two reservoir enlargement options were deferred in initial screening. Enlargement of Camp Far West Reservoir was deferred based on economic criteria. The Lower Bear River Expansion Project would increase the storage of Lower Bear Reservoir by more than 26,000 af, with a yield of approximately 20,000 af. A number of uncertainties remain for the project including water rights issues, coordination with PG&E (the reservoir's owner), and more definitive estimates of the project's drought year supply.

The Water Management Issues section described several projects for EID's service area. The El Dorado Project would offer a yield of 17,000 af for EID by modifying operations of existing facilities owned by PG&E. The project would allow the district to develop water from PG&E hydropower projects in the American River Basin, by making consumptive use of water now stored and managed for power purposes. No new diversion facilities would be required for the project. The White Rock Project, a conveyance project, would not provide additional yield, but would allow more efficient use of El Dorado Project water. Implementation of the El Dorado Project is currently on hold pending negotiations with project opponents.

New Reservoirs

Onstream Storage. An extensive re-evaluation of onstream and offstream Sacramento Valley reservoir sites is being conducted by the CALFED Bay-Delta program. Reservoir sites (such as the offstream Sites Reservoir) being evaluated as statewide water supply options are discussed in Chapter 6.

The history of local efforts to develop American River Basin water supply for rapidly growing foothill communities was discussed previously. Most recently, EID and EDCWA had considered the Texas Hill and Small Alder reservoir sites, but EDCWA did not include them as preferred alternatives in its plan for EID's service area. The drought year supplies for these reservoirs have been estimated at 9,400 af (Texas Hill) and 11,250 af (Small Alder). If implementation of EDCWA's preferred alternative does not go forward, these options may still be considered viable. Nearby, Georgetown Divide Public Utility District has examined a reservoir project on Canyon Creek. The 17,000 acre-foot reservoir site, located between the Middle and South Forks of the American River, would have estimated drought yield of 6,000 acre-feet. This project was not cost-competitive with other options available to GDPUD.

In the past, El Dorado County interests also examined the Cosumnes River Project with Amador, San Joaquin, and Sacramento counties. The proposal included five new reservoirs, with hydroelectric power generation, flood control, and recreation, to provide supplemental water supply benefits. Average-year yield of the project was estimated at 170,000 acre-feet. (The hydropower portion of the project would be necessary to make the project affordable to the local agencies.) The Cosumnes River is one of the few remaining undeveloped Sierran rivers (as was demonstrated by the extensive flooding experienced in its watershed in 1997.) Desires by environmental interests to preserve the river's free-flowing characteristics and the difficulties associated with obtaining a FERC license would likely make large-scale water development on the river infeasible. Project planning is inactive.

The Colusa Basin Drainage District has investigated two small reservoirs as part of its integrated watershed management project -- Wilson Creek Reservoir west of Orland in Glenn County, and Golden Gate Reservoir on Funks Creek near Maxwell in Colusa County. The proposed structure on Wilson Creek is an embankment dam that would create a 2,225 af reservoir. The estimated average annual runoff of the Wilson Creek Basin at the dam site is 2,420 af. The construction cost is estimated at $3.3 million, and the primary purpose of this project would be flood control. Golden Gate Reservoir on Funks Creek would be formed by a 76-foot high earthfill dam that would create a 16,850 af reservoir. This dam site is also a component of the Sites/Colusa Offstream Storage Project, a north of the Delta statewide option presented in Chapter 6. The Golden Gate Reservoir, as proposed by the Colusa Basin Drainage District, would be operated primarily for flood control but would also offer limited water supply benefits. The estimated average annual runoff of the Funks Creek Basin at Golden Gate dam is 8,550 af and the construction cost estimate for the Golden Gate Dam and Reservoir is $2.5 million. Neither of these projects is included in this Bulletin's detailed options evaluation because operation studies have not been made, and potential yields are still undetermined. These reservoirs are too small to provide carry-over storage to significantly increase drought-year water supply reliability.

The Dry Creek Project, in Lake County near Middletown, was investigated by the Department in 1965. The project was designed to irrigate 5,700 acres of agricultural lands in the Collayomi and Long Valleys in Lake County. The main project feature would be a 129 foot-high

earthfill Dam on Dry Creek (a tributary to Putah Creek) forming a 6,600 af reservoir. Updated estimates of the cost of developed water range from $150-$250 per af assuming a maximum yield of 6,600 af/yr. The USACE is conducting a reconnaissance study for a similar facility, scheduled for completion in 1998.

In 1988, the YCFC&WCD studied alternative water supply projects in the Cache Creek watershed. The study identified two onstream storage projects located in Colusa County. They are Bear Creek and Wilson Valley reservoirs, with yields of 30,000 af each, and one storage project in Yolo County, Blue Ridge Reservoir, with a yield of 100,000 af. (These reservoirs were originally investigated by the Department in the 1960s and 1970s as potential sites that could store surplus water transferred from the Eel River to the Sacramento-San Joaquin Delta for the SWP.) None of these sites are under active consideration.

Many potential Yuba River reservoir sites have been studied over the years. YCWA has been evaluating a Parks Bar reservoir site on the lower Yuba River below Englebright Dam. The potential multi-purpose reservoir would have a capacity of 640 taf, providing up to 160 taf of drought year yield. The South Sutter Water District has looked at a Garden Bar proposed irrigation water supply reservoir on the Bear River, upstream of Camp Far West Reservoir. This project is not economically feasible at this time.

Offstream Storage. YCWA completed Phase I of a feasibility investigation of the Waldo Project in August 1997. (Phase I studies included estimates of yield, conceptual designs, environmental aspects and fatal flaw evaluation.) The Waldo Project would be an offstream reservoir with the principal supply diverted from the Yuba River. Waldo Dam would be located on Dry Creek, east of Beale Air Force Base in Yuba County, and would create 300 taf of storage. Water would be diverted by gravity through a tunnel from Englebright Reservoir. The average and drought year yields of the Waldo Project for YCWA's service area would be about 145 taf and 109 taf per year, respectively. The cost of water, if served in the area of origin, would be about $110 per acre-foot.

A 1988 study by the YCFC&WCD investigated a potential offstream storage project using Thurston Lake, a natural lake in the Clear Lake watershed. The Thurston Lake pump-storage project was investigated to develop a new water supply and to reduce flooding at Clear Lake communities. The project would provide storage of up to 300,000 af and yield 60,000 af.

Water would be pumped from Clear Lake into Thurston Lake during periods of high runoff in order to reduce flood flows downstream of Clear Lake. Preliminary investigations indicate that there would be substantial leakage at the site and potential water quality problems from high boron levels in Thurston Lake.

☞Photo: Sites Reservoir site

Groundwater

The Colusa Basin Drainage District is investigating a groundwater recharge project in southern Glenn County called the Orland-Artois groundwater recharge project. It involves conversion of an abandoned gravel quarry into a groundwater recharge basin. During periods of high Sacramento River flows, water would be delivered to the site via the Tehama-Colusa Canal. A sluice gate at the Canal would be constructed to regulate flows into a 3,000 foot-long pipeline terminating at the recharge basin. Preliminary designs for this project estimate a groundwater recharge capacity of 1,500 af per season. Depending on the selected configuration of the recharge basin, the estimated cost of construction ranges from about $363,000 to $513,000. Operation and maintenance costs for the project are estimated to be $4,000 per year. Although the recharge capacity of this project has been estimated, project yields have not been determined. Evaluation of this option was deferred until operation studies are completed and project yields are determined.

The Department completed a cursory investigation of the Oro-Chico Conduit in 1997. This project would convey Feather River water in a canal running from Thermalito Forebay to the south Chico area for groundwater recharge and fishery restoration. The canal would cross numerous small ephemeral streams where water from the forebay could be released for recharge. Turnouts would provide recharge water during the spring in average runoff years and occasionally in the fall of wet years. Although project yields have not been determined for this option, cursory estimates indicate that the cost of this water would probably be in the $200 to $400/af range. This option was deferred from further evaluation because of: (1) high capital cost; (2) undetermined project yields; (3) local water agency concerns regarding operating Butte groundwater basin beyond historic levels; and (4) existing recharge in the Butte groundwater basin is sufficient for present levels of use.

Conjunctive Use

USBR, in cooperation with Ducks Unlimited, began to study a conjunctive use project within Glenn-Colusa Irrigation District. The goals of the program were to provide a long-term, reliable groundwater supply to supplement available surface water for rice straw decomposition and waterfowl habitat. The plan evaluated storing wet year surplus surface water in the groundwater basin for use during drought years. Sacramento River water would be pumped into GCID's conveyance system for delivery to recharge areas. The study concluded that the project could provide around 35,000 af for winter flooding under drought year conditions. Assuming that surplus surface water from the Sacramento River would be available for the cost of pumping during periods of high flows, the estimated cost of the developed water would be around $50/af.

The Lake County Flood Control and Water Conservation District is investigating a small conjunctive use project in Big Valley near Kelseyville. This project involves the modification of the primary spillway structure of Highland Creek Reservoir to increase storage. The additional conserved water would be released downstream during the spring and fall for groundwater recharge. Lake County is presently waiting for a reservoir yield study to determine the additional amount of water available. Current cursory estimates indicate that the project would yield 400 af at a cost of about $30/af. Because the yield of the project would be less than 1,000 af, the project was not shown in the list of options most likely to be implemented for the region.

Water Transfers

Historically, intra- and inter-district water transfers have been common among CVP water rights settlement contractors on the Sacramento River. Beyond this historic practice, there are few specific proposals for future intra-regional transfers that would provide real water. One small land fallowing program has been considered.

Bella Vista Water District, located northwest of Redding, has investigated several water transfer projects to augment its drought year supplies. The District has investigated two alternatives -- an agreement with a landowner having an adjudicated pre-1914 water right to fallow lands during drought years and to transfer the conserved water for use within the District, and District purchase of land with an adjudicated pre-1914 water right, with the water being transferred during drought years for use within the District. In both cases, the lands involved are upstream of Shasta Dam in Eastern Shasta County and the water is tributary to Shasta Lake via

the Pit River. Water transferred through Shasta Dam would require approval from the USBR. The amount of water involved in these projects ranges from 1,000 to 4,000 af.

Water Recycling

As with conservation, recycling is not a source of new supply in this region, from a statewide perspective. Recycling is a potentially important water source for local purposes, but does not create new water that would otherwise be lost to the hydrologic system.

There are several small water recycling projects in the region that serve local water management needs for agricultural, environmental, and for landscape irrigation purposes. In the 1995 base year, about 12,500 af of wastewater was recycled in the region, an amount expected to increase to 20,000 af by 2020.

Other Local Options

The YCFC&WCD has filed water right applications for supplemental water from the Sacramento River. This water is intended for beneficial use by the cities of Davis, Woodland and Winters, and for agriculture, aquaculture, and fishery use at UC Davis. YCFC&WCD also filed a similar application to divert water from Cache Creek for groundwater recharge and for replacing groundwater currently being used for irrigation near Woodland. A total of about 95,000 af has been requested under the two applications.

SCWA and its member agencies have been examining several surface water management projects to improve their water supply reliability. One potential project is an intertie to connect a Solano Irrigation District irrigation canal with the SWP's North Bay Aqueduct. Another potential SCWA project is permanent water transfers from agricultural water rights holders. The cities of Benicia, Fairfield and Vallejo (San Francisco Hydrologic Region) have filed water right applications for supplemental water from the Sacramento River, seeking a total of 31,000 af per year. Vacaville (Sacramento River Hydrologic Region) would receive 8,500 af per year from this source.

Statewide Options

SWP Supplies. As proposed, local water purveyors participating in the American Basin Conjunctive Use Program would receive 55 taf of SWP water in wet and above normal years which they will use in lieu of local surface or groundwater supplies. The project, discussed in Chapter 6, would develop 55 taf of water during drought periods to SWP contractors in other

regions. The average gain for the Sacramento Region is estimated at 26 taf, assuming deliveries to the region occur almost 50 percent of the time.

Auburn Dam. An Auburn Dam alternative has been extensively studied in the past for water supply as well as flood control purposes. In 1995 the Reclamation Board endorsed the detention dam as the preferred alternative for American River basin's flood problems. A number of local agencies had in the past expressed interest in participating to develop local water supplies. If constructed, an Auburn Dam with 850 taf of storage capacity could in addition to providing flood control, provide local yields of 70 taf and 50 taf in average and drought years, respectively. This supply is assumed to be split among water users in the Sacramento and San Joaquin river regions.

CVPIA Water Acquisitions Program. As discussed in Chapter 4, Alternative 4 was selected from among the CVPIA PEIS alternatives as a placeholder for Bulletin 160-98 future CVPIA environmental water demands because it represents the most conservative estimate of future water supply requirements. The PEIS estimates that 21,000 acres of irrigated agricultural land would be fallowed in the region to provide 87 taf per year of AFRP instream flow in the Yuba River and 33 taf per year for Level 4 wildlife refuge requirements.

Table 8-4. Options Evaluations
Sacramento River Region

Option	Rank	Cost per af ($)	Potential Gain (taf)	
			Avg	Drt
Modify Existing Reservoirs/Operations				
Reoperation of PG&E Reservoirs	L			17
New Reservoirs/Conveyance Facilities				
Dry Creek Reservoir (Lake County)	L	200	7	
Bear Creek Reservoir (Colusa County)	M	290		30
Wilson Valley Reservoir (Lake County)	M	200		30
Blue Ridge Reservoir (Yolo County)	M	480		100
Thurston Lake Pump-Storage Project	L	390		60
Parks Bar Reservoir (Yuba County)	M	*	*	160
Waldo Reservoir (Yuba County)	H	*	145	109
Texas Hill Reservoir	M	*		9
Small Alder Reservoir	M	*		11
GDPUD Diversion from Middle Fork of American River	L	330		5
Groundwater/Conjunctive Use				
New Wells (Redding, Butte, and Colusa Basins)	H	30	*	*
USBR/Ducks Unlimited Conjunctive Use	H	50	--	35
Big Valley Conjunctive Use	M	30	--	^
Other Local Options				
New Surface Water Diversion from Sacramento River and Cache Creek by YCFC&WCD	M	*	**	**
New Surface Water Diversion from Sacramento River by cities of Benicia, Fairfield, & Vallejo (Vacaville)	M	*	***	***
Statewide Options				
SWP American Basin Conjunctive Use Program	H	55	26	--
Auburn Dam	M		35	25
CVPIA Water Acquisition Program	M		120	120

* No data to quantify.

** Application for 91 taf of supplemental water.

*** Aplication for 31 taf of supplemental water; Vacaville's share is 8.5 taf.

^ Less than 1 taf.

Water Resources Management Plan for Sacramento River Region

As discussed earlier, water management planning in the Sacramento River Region has been done by federal, State, and local water agencies. In most cases, the recommendations contained in these investigations were reviewed and incorporated into the following water management plan. The Sacramento River Region is expected to experience water supply shortages during average and drought years. A portion of the shortages is due to CVPIA supplemental water needs. The majority of the remaining shortage is agricultural shortages. Table 8-5 summarizes the option categories that can most likely be implemented to meet forecasted shortages.

Table 8-5. Summary of Options Most Likely to be Implemented by 2020 Sacramento Region

Option	Potential Gain (taf)	
	Avg	Drt
Shortage *	**206**	**1,109**
Conservation	--	--
Modify Existing Reservoirs/Operations	--	--
New Reservoirs/Conveyance Facilities **	145	269
Groundwater/Conjunctive Use	--	35
Water Transfers/Banking/Exchange	--	--
Recycling	--	--
Desalination	--	--
Statewide Options	61	25
Total Potential Gain ***	206	329
Remaining Shortage	**0**	**780**

* 120 taf of shortage is CVPIA supplemental water needs; the majority of the remaining shortage is agricultural shortages.

** Average year yield of Parks Bar Reservoir has not been quantified.

*** With construction of Parks Bar and Waldo reservoirs, average water year needs of region would be exceeded, although there is a substantial drought year shortage. In average water years, the surplus water could be available for use in other regions.

Groundwater is expected to be the primary local option (within this Bulletin's planning horizon) for increasing water supplies for valley floor water users north of Sacramento. Where supplies are still plentiful and of adequate quality, groundwater has a cost advantage (especially for agricultural users) over options such as new reservoirs. Also, groundwater can be developed

incrementally by individual farms and domestic users, or by water purveyors. However, data are not available to quantify the availability of additional groundwater development.

There are two conjunctive use projects that would likely be implemented. The USBR and Ducks Unlimited conjunctive use project could provide around 35,000 af for winter flooding under drought year conditions. The SWP American Basin Conjunctive Use Program would provide 26 taf in average years.

Costs of new reservoir projects tend to be prohibitive for the agricultural water users in the region, especially when the supplies are needed primarily to meet drought year shortages. However, Lower Yuba River onstream storage at the Parks Bar site, and offstream diversion from Englebright Reservoir to Waldo Reservoir, are promising projects. They could reduce the flood threat to the Yuba City-Marysville area and downstream levee systems on the Feather and Sacramento rivers. Additionally, these two potential reservoirs could provide drought year yields of 160 taf and 109 taf, respectively. Likewise, the Auburn Dam if constructed would provide the greater Sacramento area with added flood protection as well as augment drought year supplies by 25 taf. If Parks Bar and Waldo reservoirs are constructed, average water year needs of the region would be exceeded, although a substantial drought year shortage would remain.

San Joaquin River Hydrologic Region

Description of the Area

The San Joaquin River Region is bordered on the east by the Sierra Nevada foothills and on the west by the coastal mountains of the Diablo Range (Figure 8-3). It extends from the Delta and Cosumnes River watershed to the San Joaquin River watershed near Fresno. All or portions of counties within the study area include Alameda, Amador, Calaveras, Contra Costa, Fresno, Madera, Merced, Sacramento, San Benito, San Joaquin, and Stanislaus.

Summer temperatures are usually hot in the valley, and slightly cooler in the Delta and upland areas. In the winter, temperatures are usually moderate in the valley and cool in the Delta and upland areas. Annual precipitation on the valley floor ranges from about 17 inches in the north to 9 inches in the south.

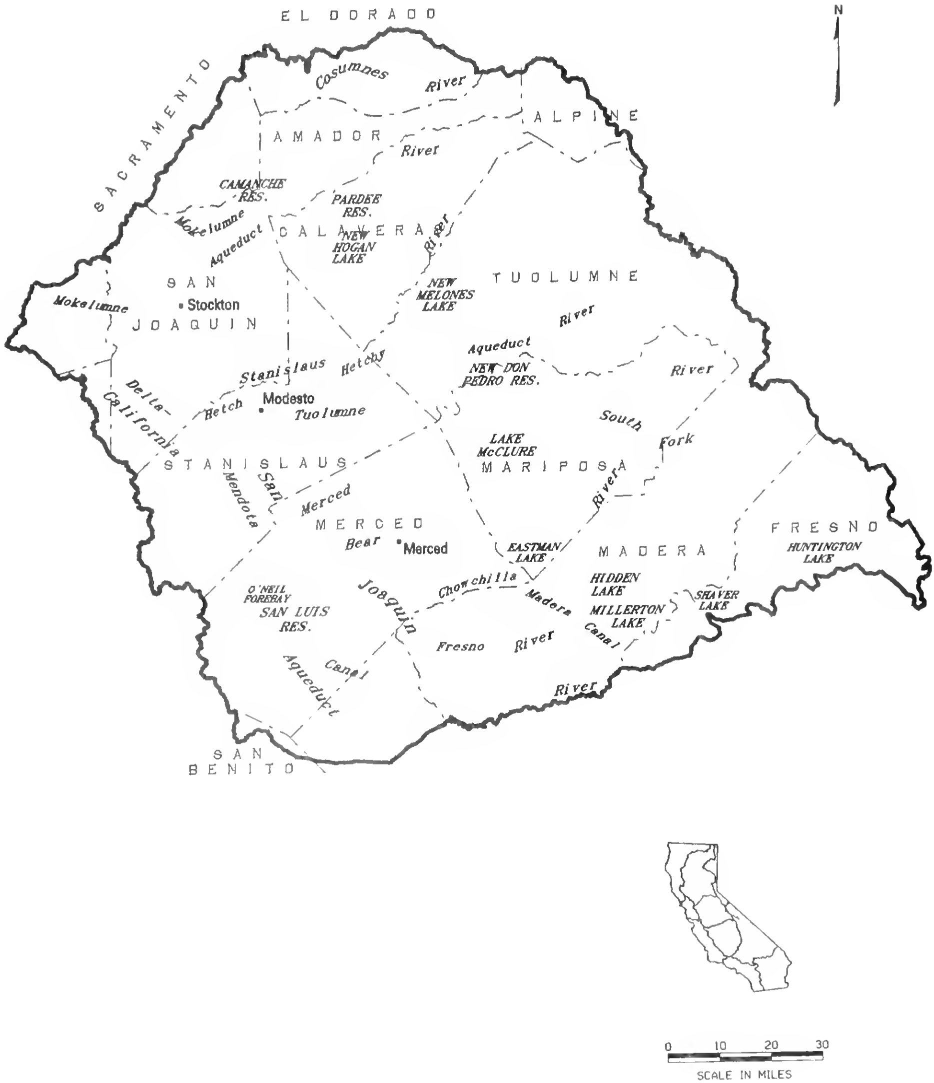
The principal population centers are the cities of Stockton, Tracy, Modesto, Los Banos, Merced, and Madera. The northwest part of the area, including Tracy and surrounding communities, is experiencing rapid growth as workers in the San Francisco Bay area accept the longer commute to the valley in exchange for the affordable housing. Table 8-6 shows the 1995 and 2020 population and crop acreage for the region.

Irrigated crop acreage in the area is forecasted to decrease primarily due to urban development on agricultural lands. The primary crops are alfalfa, corn, cotton, deciduous fruit and nuts, grain, grapes, and pasture. Major employers include agriculture, food processing, and service sector businesses.

Table 8-6. Population and Crop Acreage (in thousands)

	1995	*2020*
Population	1,592	3,025
Irrigated Crop Acres	2,005	1,935

Figure 8-3. San Joaquin River Hydrologic Region



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The area contains many wildlife refuges and wetland areas. The Grasslands area, in western Merced County, is the largest contiguous block of wetlands in the Central Valley and is a major wintering ground for migratory waterfowl and shorebirds on the Pacific Flyway. Wetlands and wildlife areas include managed wetlands on Delta islands, Grasslands Resource Conservation District, Los Banos Wildlife Area, Merced National Wildlife Refuge, North Grasslands Wildlife Area, San Luis National Wildlife Refuge, and Volta Wildlife Area. (In 1996, Kesterson National Wildlife Refuge and San Luis National Wildlife Refuge merged, with the combined refuge keeping the San Luis name.)

Water Demands and Supplies

Table 8-7 summarizes the region's water demands and supplies. Significant water shortages already occur in both average and drought years.

Table 8-7. San Joaquin River Water Demands and Supplies (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Applied Water				
Urban	574	583	954	970
Agricultural	7,027	7,244	6,450	6,719
Environmental	2,302	1,420	3,087	2,205
Total Applied Water	9,902	9,247	10,491	9,895
Supplies				
Surface Water	7,468	5,559	7,364	5,502
Groundwater	2,195	2,900	2,323	2,912
Recycled and/or Desalted	0	0	0	0
Total Supplies	9,663	8,459	9,687	8,414
Shortages	**239**	**788**	**805**	**1,481**

Surface Water

Much of the valley floor area receives its water supply from locally owned sierran reservoirs. Other reservoirs in the adjoining Sierra Nevada -- such as San Francisco's system and EBMUD's system -- export water across the region to serve Bay Area communities. Agricultural lands west of the San Joaquin Valley trough are served by the CVP. Agricultural lands in the northwest corner of this region receive their water supply by direct diversions from Delta waterways. In the foothill and mountain areas, water is either diverted directly from the area's streams and lakes or from local storage reservoirs and conveyance facilities.

In north to south order, the major sierran rivers draining to the valley floor in this region are the: Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, and San Joaquin rivers. The San Joaquin River, which forms the southerly boundary of this region, flows westward out of the mountains, then turns north and flows in the valley trough to the Delta.

The Cosumnes River, one of the smaller sierran rivers, is unique in that it has no significant reservoirs on its entire length, although it has local irrigation diversions. Riparian lands along the lower river are managed as a nature preserve. Flood protection needs on the Cosumnes were highlighted by the January 1997 floods, when numerous breaks in private levees on the valley floor caused widespread local flooding. As discussed in the following section, proposals for a managed floodway for the river are now being considered.

☞Photo: Cosumnes River flooding

The Mokelumne River system includes some hydrolelectric power development in the upper watershed, but the major reservoirs are EBMUD's Camanche and Pardee reservoirs, which develop water supply for urban communities in the East Bay. Woodbridge Diversion Dam, on the Mokelumne River near Lodi, diverts irrigation water from the river to Woodbridge Irrigation District.

The 317,000 af New Hogan Reservoir, the only large reservoir on the Calaveras River, was constructed by the USACE to provide flood protection and water supply for the Stockton area. New Hogan maintains a flood control reservation of up to 165 taf. To the south of New Hogan, Farmington Reservoir on Littlejohns Creek is a flood control detention basin also constructed by USACE to provide flood protection for the Stockton area. Stockton East Water

District, which holds a CVP contract for interim water supply from New Melones Reservoir, has been working with San Joaquin County to evaluate the possibility of modifying Farmington to provide for conservation storage in the reservoir. (SEWD already provides the city of Stockton with supply from New Hogan.) As part of its New Melones water conveyance project, SEWD constructed facilities linking Goodwin Dam on the Stanislaus River to Littlejohns Creek, and Littlejohns Creek to Farmington Reservoir.

The CVP's 2.4 maf New Melones Reservoir is the largest reservoir on the Stanislaus River. Up to 450 taf of New Melones's capacity is reserved for flood control storage. Upstream from New Melones are Beardsley Reservoir (77.6 taf) and Donnells Reservoir (57 taf), both owned by Oakdale Irrigation District and South San Joaquin Irrigation District, and both of which generate hydropower. Downstream from New Melones are Tulloch Reservoir (997 taf) and Goodwin Reservoir (68.4 taf), also owned by OID and SSJID. SSJID additionally owns the nearby 35 taf Woodward Reservoir on Simmons Creek. OID and SSJID have, by virtue of water rights agreements with USBR, the ability to carry over 200 taf of storage in New Melones Reservoir. USBR has entered into contracts with SEWD and Central San Joaquin Water Conservation District for New Melones water supply. SEWD holds a contract for 75 taf per year of interim supply from New Melones, although it has taken delivery of very little water under that contract. CSJWCD has CVP contracts for 80 taf per year, 31 taf of which is interim supply. (Interim supply in this context means supplies that are available until future in-basin demands require use of the water.) USBR must also use New Melones to meet an SWRCB salinity standard of 500 ppm on the San Joaquin River at Vernalis. As discussed in the following section, enactment of CVPIA and management of project water dedicated for environmental purposes has created conflicts in meeting the multiple needs that New Melones was intended to serve.

The Tuolumne River (the largest of the San Joaquin River tributaries) has been developed by three local agencies, including the City and County of San Francisco, which constructed Hetch Hetchy Reservoir (360 taf), Lake Lloyd Reservoir (274 taf) on Cherry Creek, and Lake Eleanor (27.8 maf) on Eleanor Creek. San Francisco also participated with the early water right holders on the river -- Modesto and Turlock irrigation districts -- in the construction of New Don Pedro Reservoir. (The reservoir is owned by the irrigation districts, but San Francisco is able to

store the water that it must provide to the prior water rights holders in New Don Pedro.) This 2 maf reservoir impounds supplies which are diverted into MID's and TID's canal systems at La Grange Dam downstream. Each of the irrigation districts has a large regulatory and offstream storage reservoir on its mainline canal downstream from La Grange -- the 29 taf Modesto Reservoir and the 45.6 taf Turlock Lake. MID serves lands north of the Tuolumne River, and TID serves lands to the south of the river.

☞Photo: Hetch Hetchy

New Exchequer Dam impounds MID's 1 maf Lake McClure, the only large water supply reservoir on the Merced River. MID has two small dams downstream to regulate flow into the District's canal system. In 1997, a small local water supply project entailing a diversion from the Merced River was completed by Mariposa Public Utility District. Mariposa PUD's project included constructing an 8-mile, 12-inch pipeline to take Merced River water to the town of Mariposa and surrounding areas.

☞Photo: New Exchequer Dam

The Chowchilla and Fresno rivers are small in comparison to their northern neighbors. Each river has only one significant water supply reservoir. Buchanan Dam on the Chowchilla River impounds the 150 taf Eastman Lake, and Hidden Dam on the Fresno River impounds the 90 taf Hensley Lake on the Fresno River. Both dams were constructed by the USACE, but their operations have been integrated with USBR's CVP. Chowchilla Water District holds a water supply contract for Eastman Lake supply, while Hensley Lake supply is contracted to Madera Irrigation District.

USBR's Friant Dam on the San Joaquin River impounds the 521 taf Millerton Lake on the San Joaquin River, which is located in the foothills just above the valley floor. (There are several hydropower reservoirs in the river's upper watershed above Friant, but there is no consumptive use of water associated with them, other than reservoir evaporation.) CVP water released from Friant is diverted into the Madera Canal to the north and the Friant-Kern Canal to the south. Chowchilla and Madera Irrigation Districts are the largest CVP water contractors on the Madera Canal. Central California Irrigation District's Mendota Dam, located on the San Joaquin River at its confluence with Fresno Slough/North Fork Kings River, forms the Mendota Pool, from which more than 20 agricultural water agencies divert their supplies. As mentioned

in Chapter 3, the CVP's exchange contractors divert Delta-Mendota water from the pool to make up for the impacts of Friant Dam construction on their prior rights to San Joaquin River water. CVP water delivered to the Mendota pool is also the source of supply for nearby USFWS national wildlife refuges.

☞Photo: Mendota Dam

Surface water supplies to the part of this region west of the San Joaquin Valley trough are provided largely by the CVP, through the Delta-Mendota Canal and San Luis Canals. CVP contractors receiving DMC supplies in the northern part of the region are small agricultural water agencies; the city of Tracy with an M&I contract of 10,000 af is the only urban CVP water user in the northern end. Although the California Aqueduct follows the Coast Range foothills along the west edge of the valley floor, there is only one SWP contractor located within this region -- Oak Flat Water District, which has a maximum contract entitlement of 5700 af. The California Aqueduct and Delta-Mendota Canal carry water diverted at the Delta into San Luis Reservoir for storage and later delivery. San Luis Reservoir is the beginning of the State-federal joint use reach of the two water projects. Lands adjacent to the San Luis Canal downstream from the reservoir are part of the CVP's service area, and receive their water supply through contracts with USBR. San Luis Water District is one of the larger CVP contractors in this area, receiving its supplies through both the DMC and the SLC.

☞Photo: DMC

Part of the southern and eastern Delta area is included in the northwest corner of this region, including such small communities as Byron, Brentwood, and Thornton. Most of this area receives its water supply from direct diversion of surface water from the Delta's many waterways. South Delta Water Agency, an agricultural water supplier, is the largest local water agency in the area. Other local agencies include East Contra Costa Irrigation District and Byron-Bethany Irrigation District.

Groundwater

Groundwater is an important source of supply for the region. Some urban areas, such as the cities of Tracy and Fresno, rely on groundwater for much of their supply. Groundwater overdraft occurs in the Eastern Valley Floor, Valley East Side, and the southern end of the Valley

West Side planning subareas. Groundwater overdraft issues in eastern San Joaquin County are discussed in the following section.

Local Water Resources Management Issues

Cosumnes River Flood Management

As noted earlier, the Cosumnes River is unique among sierran rivers for its lack of dams and related water development features. There are ongoing efforts to preserve and restore a riparian corridor along the river's path on the valley floor; the relationship of those efforts to recently emphasized floodplain management needs is being evaluated.

The Cosumnes River Preserve was dedicated in 1987 to protect existing stands of valley oak riparian forest and to restore native habitat in flood-prone agricultural fields. The Preserve, located on the eastern edge of the Central Valley between Sacramento and Stockton, is a cooperative project of nonprofit and government organizations, including the Nature Conservancy, Ducks Unlimited, US Bureau of Land Management, Department of Water Resources, Department of Fish and Game, Wildlife Conservation Board, and Sacramento County.

The Cosumnes River floods on a regular basis. The lack of upstream flood control and the consequent periodic flooding have limited urban development in the lower watershed. Much of the agricultural lands in the river's lower watershed are protected by private levees -- which experienced numerous breaks during the January 1997 floods, and caused flooding of the region's main transportation corridors. The Cosumnes River Preserve is investigating nonstructural alternatives for flood control. One alternative is the breaching of levees and establishing levee setbacks in selected areas to provide more area for the flood waters to spread. Private lands have been identified that could be acquired, depending on the willingness of sellers and on the availability of funds.

☞Photo: Preserve's riparian oak forest

Integrity of Sacramento-San Joaquin Delta Levees

There are more than 1,000 miles of levees in the Bay-Delta. Failure of Delta levees could occur as the result of catastrophic events such as earthquakes or floods, gradual deterioration of levees, and/or improper levee maintenance. Subsidence of Delta island peat soils and settling of levee foundations increase the risk of levee failure. Delta islands commonly lie 10 to 15 feet

below sea level and many are composed largely of peat soils vulnerable to seepage as well as subsidence. Levee failure could result in loss of land use on Delta islands, loss of infrastructure (EBMUD's and San Francisco's aqueducts), damage to aquatic and terrestrial habitats, reduced water supply reliability for the SWP and CVP, and impaired water quality in the Delta.

The CALFED Bay-Delta Program has identified the Delta levee system as an important resource. The Program's strategy for achieving its levee system integrity objective would be through implementation of a comprehensive Delta Levee Protection Plan. The Plan would address long-term levee maintenance, stabilization, subsidence reduction, an emergency levee management plan, beneficial reuse of dredged material, and establishment of habitat corridors as mitigation for impacts from maintenance and stabilization.

Existing programs to help maintain levee integrity in the Delta include the Department's Delta levee subventions program, which provides financial assistance to the approximately 65 percent of the Delta levees that are not part of the Sacramento River and San Joaquin River Flood Control Projects. These locally owned levees are eligible for financial assistance for maintenance and rehabilitation.

Interim South Delta Program and Temporary Barriers Project

In 1990, the Department, USBR and the South Delta Water Agency agreed to a draft settlement of a 1982 lawsuit by SDWA against the Department and USBR. The draft agreement, which focuses on short-term and long-term actions to resolve agricultural water supply problems in the south Delta, includes provisions to test and construct barrier facilities in certain south Delta channels. The testing program, referred to as the South Delta temporary barriers project, was initiated in 1991. Its objectives are the short-term improvement of water conditions for the south Delta and the development of data for the design of permanent barriers. Long-term actions are proposed through the Interim South Delta Program, as described in Chapter 6. The dual purpose of ISDP is to improve water levels and circulation in south Delta channels for local agricultural diversions and to enhance the existing water delivery capability of the SWP through improved south Delta hydraulics. ISDP's preferred alternative would cost an estimated $54 million to construct and includes five project components: (1) construction of a new intake structure at Clifton Court Forebay, (2) dredging a 4.9-mile reach of Old River from the new intake to Highway 4, (3) construction of three flow control structures at Old River, Middle River,

and Grant Line Canal, (4) construction of an operable fish barrier at the head of Old River to benefit salmon migrations in the San Joaquin River, and (5) increased diversions into Clifton Court Forebay to maximize pumping at Banks Pumping Plant.

A draft EIR/EIS for the ISDP was released in August 1996 and the public review period ended on January 31, 1997. The final EIR/EIS is scheduled to be completed in July 1998. In the meantime, installation and removal of temporary barriers in the south Delta will continue. As in previous years, the actual number of barriers installed and the installation schedule will vary with hydrologic conditions and endangered species concerns.

☞Photo: one of the temporary barriers

San Joaquin County Groundwater Overdraft

Eastern San Joaquin County has a long history of declining groundwater levels. Since the late 1940s and early 1950s, increased groundwater extraction to meet burgeoning agricultural and urban demands caused the development of two pronounced pumping depressions. The largest of these is between the Mokelumne River on the north, and the Stanislaus River on the south, and the Sacramento-San Joaquin Delta on the west. The center of this depression is east of Stockton, where groundwater levels can be more than 70 feet below sea level following the irrigation season. This pumping depression has mobilized poorer water quality from the Delta and caused it to migrate towards the city of Stockton. Several municipal wells in the western portion of Stockton have been abandoned because of the decline in groundwater quality. A second groundwater depression exists between the Cosumnes River on the north and the Mokelumne River on the south. Groundwater levels in this depression are more than 30 feet below sea level. This depression extends north into Sacramento County.

Over the years there have been attempts to quantify estimates of overdraft in eastern San Joaquin County. Recently, the Department completed studies of the area as part of the Stanislaus-Calaveras Conjunctive Use project. Data developed for this study suggested that the annual overdraft in the eastern San Joaquin County was about 70,000 af, at a 1990 level of development. A later study completed by the USBR as part of its American River Water Resources Investigation estimated overdraft at 129,900 af at a 2030 level of development. This study also concluded that 77,000 af of additional supply would be needed above the level to control overdraft to prevent the migration of poor quality water into the Stockton area.

Several possible ways for managing the overdraft are being considered, all of which entail substituting surface water supplies for groundwater use. USBR's American River Water Resources Investigation (described in the Sacramento River Region) covered parts of both the Sacramento River and San Joaquin River hydrologic regions -- portions of Sacramento, San Joaquin, El Dorado, Placer, and Sutter counties. USBR's report proposed two major alternatives for helping meet study area future water supply -- a conjunctive use alternative or a multi-purpose Auburn Dam. A third alternative, consisting of the common elements of these two alternatives, is being proposed.

San Joaquin County filed a water rights application for 322 taf during wet years from the American River through the Folsom South Canal. The existing canal would be extended, and would be used to provide supplemental supplies to reduce groundwater extraction. San Joaquin County is also interested in participating in a conjunctive use project with EBMUD, in which EBMUD's CVP contract water from the American River would be stored in San Joaquin County groundwater basins prior to being diverted into EBMUD's Mokelumne River Aqueduct in northeast San Joaquin County. This approach was one of those under consideration in EBMUD's 1995 Water Supply Action Plan described in the San Francisco Bay Region (Chapter 7). Other approaches would entail EBMUD diverting its CVP contract supply at the American River/Sacramento River confluence, rather than at the Folsom South Canal intake.

Penn Mine Remediation

Penn Mine is an abandoned copper/zinc mine first worked in the 1860s, with major activity at the site occurring in the early 1900s and during World War II. Stormwater runoff and acid mine drainage enters the Mokelumne River near Campo Seco, above EBMUD's Camanche Reservoir, and historically caused fish kills in the river from the 1930s through the 1970s. In 1978, EBMUD working in conjunction with DFG and the Central Valley RWQCB, made surface drainage improvements on the mine property and constructed Mine Run Dam on EBMUD property to provide storage and control of part of the mine runoff. In 1993, EBMUD and the RWQCB began onsite neutralization and treatment of AMD, to remove heavy metals. Litigation against EBMUD and the State of California by environmental organizations led to negotiation of an agreement among those organizations, EBMUD, California, and the U.S. EPA for selection of a long-term alternative for site remediation. An EIR/EIS completed in 1997 calls for excavation

and removal of mine waste materials at the site, removal of Mine Run Dam, and further regrading and revegetation of the site.

Conservation Storage in Farmington Reservoir

USACE is completing a reconnaissance study of flood control needs in the Stockton metropolitan area, in cooperation with the city of Stockton, San Joaquin County, and Stockton East Water District. One aspect of the study of special interest to the local sponsors is evaluation of modifying the existing Farmington Reservoir, a flood control detention basin on Littlejohns Creek, for carry-over storage.

A USACE study prepared in the 1980s suggested that the reservoir could be enlarged by as much as 160 taf to provide for conservation storage, pending geotechnical and other evaluation. USACE and the local sponsors expect to begin flood control feasibility level studies in 1997.

New Melones Reservoir Water Supply and Operations

In 1991, SEWD and CSJWCD initiated construction of facilities to convey their 155,000 af of interim CVP contract supply from New Melones Reservoir to their service areas. The two districts financed and constructed the first phase of facilities -- 21 miles of conveyance facilities -- to divert the supply into Farmington Reservoir. Much of the imported water was to be used to mitigate local groundwater overdraft problems through conjunctive use. However, very little of the interim CVP water has been delivered to the two districts because of changes in the operation of New Melones Reservoir.

Subsequent to project initiation, Congress passed the CVPIA and the SWRCB issued its May 1995 WQCP, substantially increasing environmental water requirements on New Melones and on the Stanislaus River. In 1993, the first year of implementing CVPIA's dedicated water provision, New Melones was required to release 200,000 af for fishery purposes, effectively eliminating any water which could have been allocated to SEWD and CSJWCD. Table 8-8 below shows how CVPIA dedicated water and supplemental water purchased for fishery protection were allocated at New Melones for subsequent years.

The 1995 WQCP increases demands on New Melones to meet pulse flow and salinity standards at Vernalis. Additionally, USBR/USFWS have proposed to conduct a temperature control study for the reservoir, to identify structural or nonstructural alternatives to control water

temperatures in the river downstream from the dam. Work on this appraisal-level study has not yet begun.

Table 8-8. Actual New Melones Releases (taf)

Year	Dedicated Vol	Supplemental Water Vol	Total
Mar '93- Feb '94	140.9	0.00	140.9
Mar '94- Feb '95	22.7	46.4	69.1
Mar '95 - Feb '96	146.3	4.2	150.5
Mar '96 - Feb '97	113.4	0.00	113.4

Urban Growth Pressures from San Francisco Bay Area

San Joaquin Valley communities within commuting distance of the San Francisco Bay area are experiencing rapid growth as persons who work in the Bay Area are attracted by the lower housing costs in the Valley. The Highway 4 and Altamont Pass transportation corridors provide ready access to jobs in the Bay Area. In the Tracy area, for example, urbanization has been occurring on prime agricultural lands, prompting local planners to encourage future urban development in areas and at densities that have less impact on high-value farmlands. During the real estate boom period of the late 1980s to early 1990s, there was considerable local discussion and concern over water supply availability for proposed "new towns" on the western edge of the valley. (The city of Tracy relies on groundwater and CVP contract supply to meet its water needs. Future development of groundwater in the area is constrained by poor groundwater quality.) At one point, as many as nine new communities had been proposed in southwestern San Joaquin County. Few of these communities were ultimately approved by local land use planning authorities. One proposed community, New Jerusalem, was initially approved, but an amendment to the county's general plan is now being processed to remove the community from the plan. Mountain House is one of the few "new towns" being developed.

East Contra Costa County Water Supply Management Study

The East County Water Management Association, an organization of eleven local agencies in eastern Contra Costa County, conducted a water supply management study to identify and evaluate potential water management strategies for meeting the area's future water

needs, in response to urban growth pressures in communities such as Antioch, Oakley, and Brentwood. ECWMA's member agencies are:

City of Antioch	Contra Costa Water District
City of Brentwood	Diablo Water District
City of Pittsburg	Delta Diablo Sanitation District
Byron-Bethany Irrigation District	Contra Costa County Sanitation District No. 19
East Contra Costa Irrigation District	Ironhouse Sanitary District
Contra Costa County Water Agency	

The study was conducted in two phases. Phase I, completed in 1994, provided a preliminary analysis of future demand, water supplies, existing infrastructure, and general issues related to cooperative water resources management. Phase II focused on developing, evaluating, and recommending alternatives for providing water supplies through the year 2040.

The study identified a variety of potential supplies to meet the water demands of the ECWMA's study area:

In-county surface water	Reclaimed water
In-county groundwater	Outside-county water transfers
Conjunctive use development	Water conservation

Because the ECWMA has access to significant surface water supplies through CVP contracts and local diversions, study results indicated that in-county surface water supplies could meet study area future water demands in a normal hydrologic year. However, in a drought year, deficits would occur after the year 2010.

Current groundwater use in the study area amounts to 14,500 af per year. Some areas (such as Brentwood, Discovery Bay, Bethel Island, and Hotchkiss Tract) depend entirely on groundwater. Other areas (such as Pittsburg, Antioch, and DWD) use groundwater to supplement surface water supplies. Existing groundwater quality problems in ECWMA may limit future groundwater development.

Three water supply scenarios were evaluated for the ECWMA area.

- Scenario 1--Maximized local pooling of surface water supplies. This concept would require negotiation of new agreements for the long-term transfer of surplus water supplies from two agricultural districts (ECCID and BBID) to the agencies serving ECWMA urban areas, and changes to the place of use/purpose of use in existing water rights.

- Scenario 2--Continued groundwater pumping with maximized local pooling of surface water supplies.
- Scenario 3--Continued groundwater pumping with existing levels of local pooling of surface water supplies.

Scenario 2 ranked the highest among the three scenarios. Spot water transfers and short-term demand management would provide drought year supply for this scenario.

Some specific recommendations made in the study included:

- ECWMA should commission a comprehensive groundwater study of the east county area. The study should focus on groundwater quantity and quality, and interactions between surface water and groundwater supplies. An in-county conjunctive-use program to manage dry year shortages should be evaluated.
- An aquifer storage and recovery program should be investigated in the Randall-Bold water treatment plant area, in the event that ECWMA member agencies are required to limit their Delta diversions at some times of the year.
- ECWMA members should construct dual water distribution systems to facilitate future use of reclaimed water in all water service areas within the east county.
- Interties between water treatment plant service areas increase reliability and flexibility during emergencies. The cities of Pittsburg and Antioch, CCWD, and DWD should discuss potential intertie benefits associated with CCWD's seismic and reliability improvement project.

Los Banos Grandes Reservoir Studies

One approach for providing water supply reliability and operational flexibility to the SWP is to "bank" water south of the Delta. Water banking diverts water into storage during high flow periods for later release during dry periods. The Department has conducted a number of studies to evaluate potential water banking sites, as described in Chapter 6. These studies led to a December 1990 Los Banos Grandes Facilities Feasibility Report, which recommended construction of a 1.7 maf reservoir and associated facilities on Los Banos Creek in western Merced County.

Currently the Department has placed this project on hold, and will reassess the feasibility of constructing Los Banos Grandes facilities or alternative south-of-the-Delta water banking

facilities once CALFED has identified a preferred Delta solution. The proposed location and size of the facilities would be reevaluated, taking into consideration future Delta water export restrictions, changes in environmental regulations and permit processes, and the needs and financial capabilities of the SWP contractors.

Merced Area Conjunctive Use Study

In 1993, the city of Merced and Merced Irrigation District began a two-year water supply planning process for eastern Merced County through 2030. The goals of the study were to: manage groundwater; provide a high quality, reliable water supply for cities; protect and enhance the economic base of the region; protect MID's water rights for the benefit of the entire region; and maintain consensus for the plan. The advisory committee selected a groundwater recharge option as the preferred alternative. The groundwater basin would be operated in combination with a surface water storage and conveyance system. Studies to determine groundwater recharge quantities and locations are currently being performed.

Managing Agricultural Drainage Discharges to the San Joaquin River

There have been significant efforts to manage saline drainage water in the region. The San Luis Drain, on which USBR began construction in 1968, was to be used to transport tile drain water from the region to Suisun Bay. The segment of the drain initially constructed by USBR was closed in 1986 as a result of the discovery of selenium problems at USBR's Kesterson Reservoir. This has made it essential for agricultural districts to manage irrigation applications as efficiently as possible onsite until a regional solution for drainage management and disposal is developed.

Some agricultural water districts in the region discharge drainage water and associated salts to the San Joaquin River. Much of the salt and selenium loads in the San Joaquin River originate from Grassland's water supply canals and from two sloughs tributary to the river -- Mud and Salt sloughs. Prior to the construction of upstream water storage facilities, the San Joaquin River Region flooded frequently, leaching salts from the floodplain and discharging them into the Delta. With irrigation supplies bringing in salts from the Delta, salts now accumulate more rapidly and are leached less frequently. Exacerbating the salt accumulation problem is the fact that much of the San Joaquin River's flow is in effect recirculated by the CVP/SWP pumping plants in the south Delta.

Grassland Bypass Channel Project. Agricultural drainage from the Grasslands basin was historically discharged to natural channels that meandered through Grasslands Water District and eventually to the San Joaquin River through Mud and Salt sloughs. In an attempt to manage selenium loads entering the San Joaquin River, USBR designed, and is presently evaluating, the Grasslands Bypass project. To undertake this five year demonstration project, a new channel approximately two miles in length was constructed to intercept drainage water that would otherwise flow towards Grasslands Water District. The new channel feeds into the existing San Luis Drain and allows the drainage water to discharge directly to the San Joaquin River through Mud Slough.

To discharge drainage water into the San Luis Drain, a use agreement was signed by USBR and the San Luis and Delta-Mendota Water Authority, whereby a drainage incentive fee system was established to provide monetary incentives for reduction of selenium loads discharged to the San Luis Drain. The project, which became operational in October 1996, has significantly reduced salt and selenium loads entering Grasslands Water District and Salt Slough. The fee system identifies a tiered system of financial liability associated with exceedance of monthly and annual selenium concentration (Table 8-9). These concentrations (load values) are in accordance with the Regional Water Quality Control Board waste discharge requirements for the discharge of agricultural drain water. Tables 8-10 and 8-11 show the monthly and annual exceedance fees developed by USBR. If load targets are exceeded by more than 20 percent in any given year, the project may be terminated at the discretion of the USBR. An interim review of project performance will be conducted after two years of operation.

Table 8-9. Selenium Load Values

Month	2-Year Load Values (Se lbs) 10/95-9/97	3-Year Load Values (Se lbs) 10/97-9/98	4-Year Load Values (Se lbs) 10/98-9/99	5-Year Load Values (Se lbs) 10/99-9/00
October	348	348	348	348
November	348	348	348	348
December	389	389	389	389
January	533	506	479	453
February	866	823	779	736
March	1,066	1,013	959	906
April	799	759	719	679
May	666	633	599	566
June	599	569	539	509
July	599	569	539	509
August	533	506	480	453
September	350	350	350	350
12-month total	7,096	6,813	6,528	6,246
Annual Load Values	6,660	6,327	5,994	5,661

Table 8-10. Monthly Exceedance Fees (Dollars)

Year	0.1 - 10%	10.1 - 15%	15.1 - 20%	20.1 - 25%	25+ %
1	700	1,400	2,100	2,800	2,800
2	1,200	2,200	3,200	4,200	4,200
3	5,200	7,600	10,100	12,500	12,500
4	6,800	10,100	13,400	16,700	16,700
5	8,300	12,500	16,700	20,800	20,800

Table 8-11. Annual Exceedance Fees (Dollars)

Year	0.1 - 5%	5.1 - 10%	10.1 - 15%	15.1 - 20%	20+%
1	25,000	50,000	75,000	100,000	100,000
2	44,000	79,000	115,000	150,000	150,000
3	63,000	92,000	121,000	150,000	150,000
4	81,000	121,000	160,000	200,000	200,000
5	100,000	150,000	200,000	250,000	250,000

San Joaquin River Real Time Drainage Monitoring Program. Participants in the San Joaquin River Management Program set up a network of telemetered flow and salinity monitoring stations on the San Joaquin River. Data from the stations are linked to a flow model of the San Joaquin River and its tributaries (the San Joaquin River Input-Output Model, adapted to a daily time-step, SJRIODAY). Information from the model is distributed to water managers by E-mail. A demonstration of the real-time monitoring effort was carried out in February 1996. Grasslands Water District managers were informed that SJRIODAY forecasted a major increase in flow in the river. The district discharged a significant amount of high salinity water from its waterfowl ponds by partially draining them with the high flow event. This timed discharge enabled better quality water to be maintained in the San Joaquin River later that spring. A significant portion of the salt load from Grasslands had already passed through the system by the time agricultural diversions began.

Enlargement of Friant Dam

Potential enlargement of Friant Dam has been mentioned in the past in terms of possible water supply augmentation. More recently, needs for fishery flows and improved management of winter/spring floodwaters have been emphasized. Millerton Lake has a relatively small storage capacity relative to the river's average annual flow. USBR had performed an evaluation in the 1980s of potential yield increases associated with enlarging the existing 521 taf reservoir by increasing the height of the dam about 140 feet. The Department's 1995 SJRM Plan included a recommendation that enlarging Friant for multipurpose use be studied. As has been commonly acknowledged, the San Joaquin River is already oversubscribed with respect to the water supplies desired from it. Potential benefits mentioned from raising Friant Dam have include water supplies that could be made available for CVP water users, for downstream riparian diverters, for helping meet SWRCB salinity and fishery flow requirements at Vernalis, and for dilution of agricultural drainage flows discharged to the river. These supplies could be achieved through storing winter floodwaters, which would provide flood control benefits for lands in the lower watershed. An issue that will need to be addressed is instream flows in the river immediately downstream from the dam, as described below.

Instream Flow Requirements Below Friant Dam

In December 1988, the Natural Resources Defense Council filed a suit in U. S. District Court, seeking an injunction and declaratory judgment to prevent the USBR from renewing long-term CVP water supply contracts without preparing environmental documentation and to require more releases for instream uses from Friant Dam, based on Fish and Game Code Section 5937 and the public trust doctrine.

The legal issues are:

(1) Does federal law require the USBR to renew the water contracts subject to NEPA and ESA review?

(2) Does Fish and Game Code Section 5937 apply to federal projects?

(3) Has the CVPIA preempted Fish and Game Code Section 5937?

The District Court found that CVPIA passage had not caused NRDC's NEPA and ESA claims to be moot. Also, the CVPIA had not preempted plaintiff's claim under Fish and Game Code Section 5937. In January 1997, the federal court ruled that the USBR failed to comply with Section 7 of the ESA when it renewed contracts without consulting with appropriate federal wildlife regulatory agencies. The court declared all contracts renewed before the passage of the CVPIA invalid. The case is being appealed to the Ninth Circuit Court of Appeals.

Apart from the litigation, USBR has also proposed to study the possibility of reoperating privately owned hydropower reservoirs upstream of Millerton Reservoir, to see if their operations could be coordinated with irrigation releases from Millerton to provide instream flows below Friant Dam. Under CVPIA's anadromous fish restoration program, USBR and USFWS have authority and funding to acquire, from willing sellers, supplemental fishery water supplies. USFWS has also indicated that FERC's relicensing process for hydropower plants is a tool available to provide instream flows recommended in the AFRP.

Environmental Restoration Activities in San Joaquin River and Tributaries

Numerous restoration projects have been implemented in the recent past by local, State and federal agencies on the San Joaquin River and its tributaries in an effort to enhance fish and wildlife. Other actions are ongoing, and others are being planned. The adoption of the SJRM Plan, enactment of the CVPIAct, the 1994 Bay-Delta Accord and the Four-Pumps Agreement

between the Departments of Fish and Game and Water Resources have all contributed to the planning, funding, and implementation of these restoration activities.

Examples of completed restoration actions include:

(1) A Stanislaus River spawning gravel restoration project on the lower Stanislaus River was completed in September 1996. This project consisted of constructing riffles and placing gravel for salmon spawning habitat at three sites, River Miles 47.4, 50.4, and 50.9.

(2) A Merced River Spawning Gravel Restoration Project below Crocker-Huffman Dam on the Merced River was completed in 1990 and repaired in September 1996. An earlier spawning gravel restoration project had also been completed in the Merced River in 1991.

(3) The Magneson Pond Isolation Project (Merced River) was completed in 1996 and consisted of isolating a gravel pit from the river and replacing spawning gravel.

(4) Phases I and II of habitat restoration project development studies have been completed for the Ratzlaff Reach and the lower W. Stone predator removal and spawning habitat restoration projects on the Merced River, scheduled for construction in 1998 and 1999, respectively. These projects will consist of isolating gravel pits from the river flow and placing spawning gravel in the river.

(5) The M. J. Ruddy spawning gravel project was completed in 1993 on the Tuolumne River. Another project was completed in September 1996, consisting of constructing equalization channels along the levees of the river above the M. J. Ruddy project, designed to equalize river flows to protect the spawning habitat from washout.

(6) The La Grange spawning riffle project, completed in 1994, consisted of constructing riffles and placing spawning gravel at three sites along the Tuolumne River.

(7) Funds from the Four-Pumps Agreement have been used since 1994 to support one DFG warden assigned to enforce fishing regulations (reduce poaching of anadromous fish) in the San Joaquin River and its tributaries.

(8) Construction of temporary physical fish barriers at Hills Ferry on the San Joaquin River (downstream of the mouth of Merced River) and at the head of Old River in the Delta. These fish barriers are constructed and removed on a seasonal basis every year.

(9) Implementation of the CVPIA dedicated water provision and the Bay-Delta Accord has increased instream flows in the San Joaquin River. Spring pulse flows have also been provided.

(10) The Tuolumne River Settlement Agreement among city and county of San Francisco, Turlock Irrigation District, Modesto Irrigation District, and FERC will result in increased fish releases from New Don Pedro Reservoir that will reduce fish stranding losses and increase instream flows.

Several programs are underway to provide fishery benefits in the region, including the CVPIA's anadromous fish restoration program plan, Four-Pumps Agreement projects, and the Bay-Delta Accord's Category III program. Examples of ongoing fish restoration projects include:

(1) The Category III program has contributed funding for a feasibility study to construct a fish screen at Banta-Carbona Irrigation District's Main Lift Canal intake channel on the San Joaquin River. The CVPIA Anadromous Fish Screen Program may cost-share in construction of the facility.

(2) Plans for the construction of Tuolumne Fish Hatchery are underway, although several environmental hurdles still need to be addressed before a final decision is made to actually build the fish hatchery. Land for the hatchery was acquired in 1996 by the Four-Pumps program.

(3) USBR is preparing plans to replace CCID's Mendota Dam. Replacement of the dam will benefit fish and wildlife by allowing fish passage, avoiding release of accumulated sediments downstream, and providing increased water supply to Mendota NWR.

(4) Spawning gravel habitat restoration and predator isolation and habitat removal projects have been approved for construction on the San Joaquin, Tuolumne, Merced and Stanislaus Rivers through the Four-Pumps Agreement. The CVPIA spawning gravel program will fund spawning gravel placement in the Stanislaus River below Goodwin Dam and will prepare a long-term spawning habitat restoration plan for the Stanislaus River.

(5) Plans are underway to restore the channel of a six-mile stretch of the Tuolumne River by DFG and USFWS, as an AFRP project. The project will consist of isolating or filling gravel pits along the river, and restoration of spawning gravel habitat.

Wetlands/Wildlife Refuge Water Supply Issues

Within the San Joaquin Region, total current wetland water use is estimated at 4.42 af/acre, with an optimum water use of 6.55 af/acre (a deficit of 2.13 af/acre). Of the total wetlands in the San Joaquin Region, approximately 40,700 acres are privately owned. On the private parcels, additional water required to meet wetland needs amounts to 86,700 af. Publicly managed freshwater wetlands in the San Joaquin Region include: North Grasslands WA, Kesterson NWR, Arena Plains NWR, San Luis NWR, Merced NWR, Volta WA and Los Banos NWR.

January 1997 San Joaquin River Region Flood Event

The New Year's Day Flood of 1997 was notable for the sustained intensity of the associated rainfall, the volume of floodwater, and the areal extent of the storm pattern -- from the Oregon border down to the southern end of the Sierra. Over a three day period, warm moist winds from the southwest blew over the Sierra Nevada and poured more than 30 inches of rain on watersheds already saturated by one of the wettest Decembers on record. Sheer volume of runoff exceeded the flood control capacity of New Don Pedro Reservoir on the Tuolumne River and Millerton Lake on the upper San Joaquin River. While the peak flood release from New Don Pedro Dam was less than half the peak Tuolumne River inflow of 120,000 cfs, it was more than six times the downstream channel design capacity of 9,000 cfs. In all, thirty-six levee failures occurred along the San Joaquin River system, along with extensive damage related to high flows and inundation. Most of the damage occurred downstream of the Tuolumne River confluence.

The primary flood control issue facing the San Joaquin River Region is the lack of flood channel capacity. Channel levees are generally designed for 50-year flood protection. Lack of channel capacity is especially problematic in the lower San Joaquin River below the Merced River. At the lower end of the system, sediment deposition continues to raise the river bed and lower flood protection. Sediment deposition reduces channel cross sectional flow area and promotes vegetation growth, thereby increasing channel roughness and further impeding flows.

As urban development occurs on lands formerly used for agriculture, the need for higher level of flood protection becomes more pressing.

The 1997 *Governor's Flood Emergency Action Team 1997 Final Report* detailed several recommendations and possible actions for the San Joaquin River watershed, such as:

- A USACE reconnaissance study for the Tuolumne River which would include evaluation of constructing a flood control impoundment on Dry Creek, developing off-stream flood storage to be integrated with water supply storage, and restricting development in the flood plain.
- Acquisition of flood-prone lands (largely agricultural lands) in Stanislaus County which could be added to USFWS's San Joaquin National Wildlife Refuge. The lands would be managed to allow periodic flooding, and would provide temporary storage of flood peaks. Likewise, a similar approach could be taken at the West Bear Creek Unit of the San Luis National Wildlife Refuge, where floodflows could, with the provision of the necessary control facilities, be temporarily stored on existing refuge lands.
- Increasing the capacity of the lower San Joaquin River by measures such as channel dredging, setback levees, and improving bridge crossings.

Water Management Options for the San Joaquin River Region

Table 8-12 shows a comprehensive list of options for the region, and the results of an initial screening. The option evaluation scoring is shown in Table 8A-2 in Appendix 8A.

Water Conservation

Urban. Urban water conservation options were deferred from evaluation because there is little potential to create new water (reduce depletions) from them in the San Joaquin River region.

Agricultural. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Changes in irrigation management practices to attain seasonal application efficiencies of 76 to 80 percent would yield less than 1 taf depletion reduction. Flexible water delivery, canal lining and piping, and tailwater recovery, could each yield 2 taf per year depletion reduction.

Table 8-12. Comprehensive List of Options
San Joaquin River Region

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to 0.8 ET_o	Defer	No substantial depletion reductions attainable.
	Residential Indoor Water Use	Defer	No substantial depletion reductions attainable.
	Interior CII Water Use	Defer	No substantial depletion reductions attainable.
	Distribution System Losses	Defer	No substantial depletion reductions attainable.
Agricultural			
	Seasonal Application Efficiency Improvements	Defer	No substantial depletion reductions attainable.
	Flexible Water Delivery	Retain	
	Canal Lining and Piping	Retain	
	Tailwater Recovery	Retain	
Modify Existing Reservoirs/Operations			
	Reoperate/Enlarge Farmington Reservoir	Retain	
New Reservoirs/Conveyance Facilities			
	Montgomery Reservoir Offstream Storage	Retain	
	Fine Gold Creek Offstream Storage	Retain	
	Irish Hill Reservoir	Retain	
	Volcano Reservoir	Retain	
	Middle Bar Reservoir	Retain	
	Devil's Nose Reservoir	Retain	
	Cape Cod Reservoir (Cosumnes River)	Defer	Major storage unlikely on Cosumnes River.
	Bakers Ford Reservoir (Cosumnes River)	Defer	Major storage unlikely on Cosumnes River.
	Mid-Valley Canal	Defer	Questionable water supply availability. No longer viable as local option.
Groundwater/Conjunctive Use			
	EMBUD/San Joaquin County Conjunctive Use	Defer	Yields undefined.
Water Transfers/Banking/Exchange			
	---	---	---
Water Recycling			
	---	Defer	By definition in this Bulletin, does not generate new water.
Desalination			
Brackish Groundwater			
	Agricultural Drainage		High costs and lack of a clearly defined brine disposal alternative.
Seawater			
	---	---	---
Other Local Options			
	---	---	---
Statewide Options			
	Auburn Dam	Retain	
	Enlarge Friant Dam	Retain	
	CVPIA Water Acquisition Program	Retain	

Modify Existing Reservoirs

Various agencies have looked at raising or modifying existing water supply and/or multi-purpose reservoirs. The USACE is updating 1980s information on increasing Farmington Reservoir's storage capacity. Local runoff, plus New Melones spills or American River imports, could be used to fill the enlarged reservoir. The estimated cost for modifying this reservoirs is up to $700/af.

Central California Irrigation District is working with USBR to use CVPIA funding to replace the existing Mendota Dam. The replacement is necessary for a variety of reasons including dam safety considerations, wildlife enhancement, and regulation of wildlife refuge water levels. Replacement of the dam is estimated at $1.2 million. The replacement would not provide new water supply, but would allow better regulation of existing supplies.

New Reservoirs

Over the years local agencies, as well as regional, State, federal, and private water purveyors, have studied various reservoir sites in the area. The studies have focused on water supply, power generation, flood control, recreation, and other benefits. Some of the studies envisioned multi-purpose development and multi-agency participation.

Amador County Water Agency had developed preliminary proposals for the Irish Hill and Volcano reservoir projects. Irish Hill Reservoir, on Dry Creek, would serve areas near Ione with up to 23,700 af of drought year supply. Volcano Reservoir, on Sutter Creek, would serve the communities of Sutter Creek and Amador City, in addition to providing flood control benefits for Sutter Creek. The estimated drought year supply would be 14,700 af. The county had also participated in studies of the larger Middle Bar and Devil's Nose reservoir projects. Alternatives for Middle Bar include a low dam, with a drought year supply of 12,000 af and a high dam, with a drought year supply of 159,000 af. The larger Middle Bar Dam could potentially be constructed by EBMUD primarily for their supply, but could provide some local supply to Amador, Calaveras, and possibly San Joaquin counties. A number of obstacles such as water rights, a FERC license, and financing would need to be addressed. Devil's Nose is a 145,000 acre-foot reservoir proposal on the North Fork and main stem of the Mokelumne River. Again, the size of the project would probably require participation by other agencies. Both projects are currently inactive.

The Cosumnes River Project, originally envisioned to be a four-county multi-purpose project, would include up to six reservoirs with various appurtenant power generation, tunnel and pipeline, transmission, and related facilities. The larger potential reservoirs, located on the main and middle forks of the Cosumnes River, include the 300 taf Cape Cod and 185 taf Bakers Ford reservoirs. Portions of the Cosumnes River Project could be developed by local or regional water agencies. Two additional offstream projects include the Montgomery Reservoir Offstream Storage and the Fine Gold Creek Offstream Storage Project are discussed in detail below.

Montgomery Reservoir Offstream Storage Project. The Montgomery offstream reservoir would be constructed on Dry Creek, north of the confluence of Merced River and Dry Creek near the community of Snelling. The reservoir would store spills from Lake McClure for municipal and agricultural uses. Alternatively, reservoir operation for the primary purpose of providing environmental benefits has also been considered. Water would be conveyed by a two-way facility from Merced Falls Diversion Dam to Montgomery Reservoir. Releases from New Exchequer Dam would improve instream flows and maintain a lower water temperature to benefit fall run chinook salmon in the Merced River. The reservoir would also provide additional flood protection in the San Joaquin River. The reservoir would have a capacity of 240,000 af. About $3 million will be required to complete the feasibility study. The project including the dam reservoir, conveyances, pumping and appurtenant facilities, has been estimated to cost about $135 million. Three years would be required to complete the feasibility investigations and environmental compliance work. The yield is estimated to be 35 taf during drought years. The drought year cost of this option is estimated to be $300/af.

Fine Gold Creek Offstream Storage Project. In 1989 Madera Irrigation District requested the USBR to investigate a pump/storage project on Fine Gold Creek. The project, a 350,000 af offstream storage reservoir and powerhouse, would be constructed on Fine Gold Creek, a San Joaquin River tributary. During periods of flooding, water would be pumped from Millerton Lake into the reservoir for future water supply and power generation. Potential benefits include fishery enhancements and flood control and protection. The average year yield is estimated to be 42 taf. According to MID's 1991 preliminary cost estimate, the project would cost in excess of $500 million. Project evaluation and investigation was estimated at $3 million, and at least 3 years would be required to complete feasibility and environmental investigations.

The Fine Gold Creek project, although not originally formulated as such, is essentially an alternative to enlarging Friant Dam.

New Conveyance Facilities

Since the 1970s several studies have been conducted on the feasibility of importing additional Delta supplies to reduce groundwater overdraft in the San Joaquin Valley. In USBR's 1981 *A Report on the Mid-Valley Canal Feasibility Investigation*, the possibility of constructing a canal that would supply portions of Madera, Merced, Fresno, Kings, Tulare and Kern counties with additional imported water was investigated.

The report suggested that water from the Delta could be conveyed to O'Neill Forebay using available capacity in the California Aqueduct. From O'Neill, a portion of the water would be delivered to the Mendota Pool by an enlarged Delta-Mendota Canal, while the remainder would be conveyed to Kern County by using extra capacity in the California Aqueduct. To provide water to rest of the service area, the proposal called for the construction of two branches of a new facility called the Mid-Valley Canal. The Main Branch would lift water from the Mendota Pool and carry it southeast to Fresno, Kings, and Tulare Counties. Madera and Merced Counties would receive their supply via a North Branch, also diverting from the Pool. The introduction of this additional water supply to the San Joaquin River Region would provide the primary benefits of reducing of groundwater overdraft. Other benefits from the project could include reduction of land subsidence due to groundwater extraction, enhancement of wetlands, wildlife habitat, and recreational facilities.

Initially the USBR identified a firm annual water supply in the Delta of approximately 500,000 af as available for export to the proposed service area. It was determined that this supply was unavailable due to increased Delta outflow requirements and curtailment of proposed expansion of CVP facilities that could have provided increased yield. Enactment of CVPIA further limited available CVP water supply. Nevertheless, if a supply could be found for the project, a Mid-Valley Canal facility could provide a variety of benefits to the San Joaquin Valley.

Groundwater/Conjunctive Use

In the San Joaquin River Region, urban and agricultural water users have relied on both surface and groundwater supplies to meet their water demands. Groundwater usage within the

region varies depending upon the availability of surface water. Many local water purveyors within the region utilize surface water allocations, purchased water, and excess flood water for groundwater recharge. Within the region, natural waterways, local agency canals, and State and federal conveyance facilities create opportunities for groundwater recharge, storage and conjunctive use programs.

EBMUD continues negotiations with San Joaquin County interests for a joint groundwater storage/conjunctive use project. This option is part of the EBMUD's Water Supply Action Plan and the yield is undefined at this time.

Water Recycling

In the San Joaquin River Region most municipal and industrial water use occurs on the east side of the San Joaquin Valley. The wastewater produced is generally spread for groundwater recharge. Wastewater that is directly or indirectly discharged to the San Joaquin River becomes available for downstream uses, including Delta outflow requirements. Because of the extensive reuse or basin outflow, there are no water recycling options within the basin which qualify as new sources of supply.

There are several small water recycling projects that serve local water management or wastewater disposal needs. At several of the larger cities and towns in the Eastern Valley Floor planning subarea, wastewater is currently collected, treated, and utilized for golf course or pasture irrigation. The City of Stockton proposes to utilize treated wastewater for additional agricultural irrigation, groundwater storage, or transfer to possible future storage reservoirs or Farmington Reservoir. Another alternative for Stockton would be to discharge treated wastewater to the Delta, in exchange for direct diversion of river surface water.

Groundwater Desalination

In the San Joaquin River Region there are an estimated 150,000 acres of land where the depth to groundwater is 20 feet or less. The 1991 Interagency Drainage Program report projected that this area of shallow groundwater could grow to 250,000 acres by 2040, if no drainage management actions were taken. Studies have indicated that groundwater recovery by desalting could cost up to $1,000/af, if a brine disposal option were available. This option is deferred due to high cost and lack of a clearly defined brine disposal alternative.

Statewide Options

Enlarge Friant Dam. Recent interest has been expressed in enlarging Friant Dam (an option studied by USBR in the past). Raising Friant Dam would potential have flood control, water supply, and water quality benefits. Enlarging Friant Dam could provide 25 taf of drought year supply to the region.

Auburn Dam. As discussed in the Sacramento River Region, the Auburn Dam alternative has been extensively studied in the past for water supply as well as flood control purposes. If constructed an Auburn Dam with 850 taf of storage capacity could in addition to providing flood control, provide local yields of 70 taf and 50 taf in average and drought years respectively. This supply is assumed to be split among water users in the Sacramento and San Joaquin river regions.

CVPIA Water Acquisitions Program. As discussed in Chapter 4, Alternative 4 was selected from among the CVPIA PEIS alternatives as a placeholder for Bulletin 160-98 future CVPIA environmental water demands because it represents the most conservative estimate of future water supply requirements. The PEIS estimates that 118,000 acres of irrigated agricultural land would be fallowed in the region to provide 674 taf per year of AFRP instream flow (in the Merced, Tuolumne, Stanislaus, Calaveras and Mokelumne rivers) and 68 taf per year for Level 4 wildlife refuge requirements.

Water Resources Management Plan for the San Joaquin River Region

The forecasted shortage for the region in 2020 is 0.8 maf and 1.5 maf in average and drought years respectively. The majority of the average year shortages are due to CVPIA supplemental water needs, the remaining average year shortages are due to groundwater overdraft. Table 8-13 summarizes the results and ranking of options by option category, including cost/af estimates and potential gain. Table 8-14 summarizes the option categories most likely to be implemented to relieve the forecasted shortages.

Nearly all identified options likely to be implemented involve modifying existing or constructing new reservoirs. Reoperating or enlarging Farmington Reservoir for carryover storage would augment drought year supplies by 25 taf. Constructing Montgomery Reservoir could augment local drought year supplies by about 35 taf. As statewide options, enlarging Friant

Dam and constructing Auburn Dam for flood control purposes could provide 50 taf of additional drought year supply for the region. Even with these, there remains a large shortage in the region.

**Table 8-13. Options Evaluation
San Joaquin River Region**

Option	Rank	Cost per af ($)	Potential Gain (taf)	
			Avg	Drt
Conservation				
Agricultural				
Flexible Water Delivery	M	1,000	2	2
Canal Lining and Piping	M	1,200	2	2
Tailwater Recovery	H	150	2	2
Modify Existing Reservoirs/Operations				
Reoperate Enlarge Farmington Reservoir	M	700	*	25
New Reservoirs/Conveyance Facilities				
Montgomery Reservoir Offstream Storage	H	300	*	35
Fine Gold Creek Offstream Storage	M		42	
Irish Hill Reservoir	M	430	33	24
Volcano Reservoir	M	350	10	15
Middle Bar Reservoir	L		--	159
Devil's Nose Reservoir	L		*	25
Statewide Options				
Auburn Dam	M		35	25
Enlarge Friant Dam	M		--	25
CVPIA Water Acquisition Program **	M		742	742

* Data not available.

** If implemented, there would be a corresponding reduction in agricultural demands within this region.

Table 8-14. Summary of Options Most Likely to be Implemented by 2020 San Joaquin River Region

Option	*Potential Gain (taf)*	
	Average	*Drought*
Shortage *	**805**	**1,481**
Conservation	2	2
Modify Existing Reservoirs/Operations	--	25
New Reservoirs/Conveyance Facilities	--	35
Groundwater/Conjunctive Use	--	--
Water Transfers/Banking/Exchange	--	--
Recycling	--	--
Desalination	--	--
Statewide Options	35	50
Total Potential Gain	37	112
Remaining Shortage	**768**	**1,369**

* 742 taf of shortage is CVPIA supplemental water needs.

Tulare Lake Hydrologic Region

Description of Area

The Tulare Lake Region (Figure 8-4) includes the southern half of the San Joaquin Valley and the watershed ranges that surround it. It begins in the north below the San Joaquin River watershed and extends south to the Tehachapi Mountains. The region is bounded to the east by the Sierra Nevada Crest and by the Temblor Range in the west. The climate for the valley varies from fog shrouded winters to long, hot summers. Typically, the valley receives about 6 to 11 inches of rainfall annually, while the average precipitation in the mountains range from 12 to 36 inches, mostly in the form of snow. Most of the region's population is located on the east side of the valley where agricultural communities have developed. The area includes several rapidly growing cities, the largest of which are Fresno, Bakersfield, and Visalia. Other population centers include Hanford, Coalinga, Clovis, Taft, Wasco, Shafter, and Delano. Table 8-15 shows 1995 and 2020 populations and crop acreages.

There are several managed wetlands areas in the region, including Pixley National Wildlife Refuge, Kern National Wildlife Refuge, and Mendota Wildlife Management Area.

Table 8-15. Population and Crop Acreage (in thousands)

	1995	*2020*
Population	1,738	3,296
Irrigated Crop Acres	3,127	2,985

Most major employment sectors in Tulare Lake Region revolve around agriculture, although the petroleum industry is important in parts of the valley's west side and in Kern County. (In the relatively sparsely populated areas on the west side of the valley, industrial water demands for petroleum recovery and production exceed municipal water demands.) Most of the land area in the valley not devoted to urban and industrial purposes is used for agriculture. The predominant crop is cotton, followed by permanent orchards and vineyards. (Major orchard cops are almonds and pistachios.) Other major crops alfalfa and pasture, grain, corn, and field and truck crops.

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Groundwater/Conjunctive Use	--	--
Water Transfers/Banking/Exchange	--	--
Recycling	--	--
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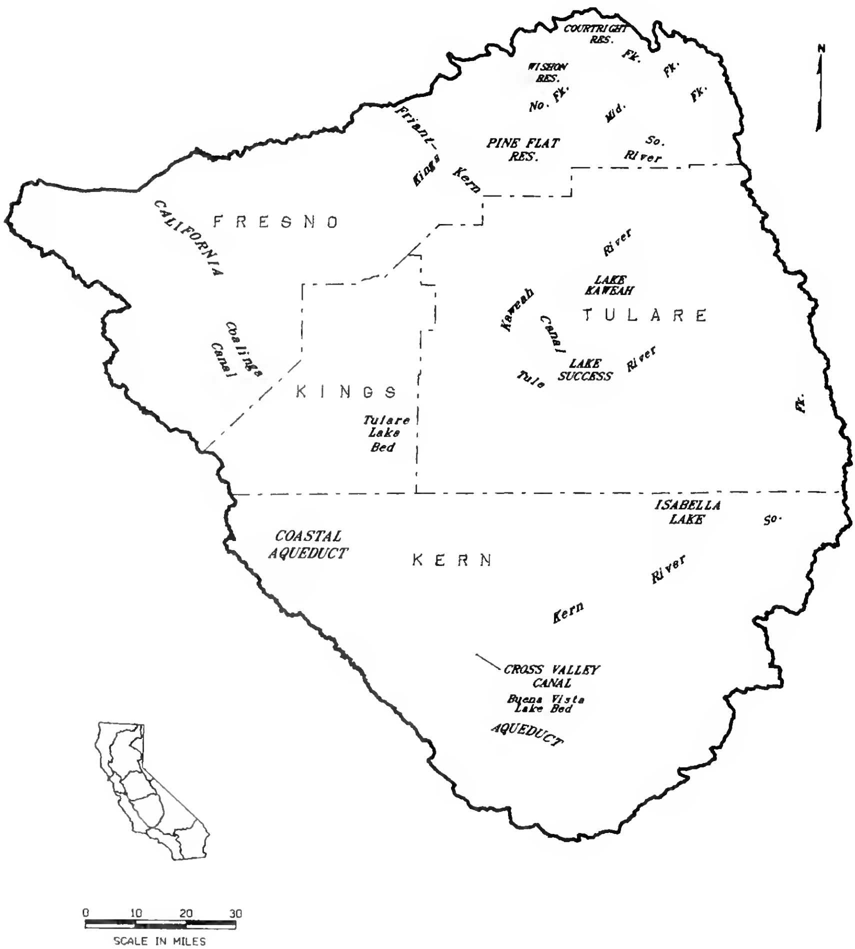
Figure 8-4. Tulare Lake Hydrologic Region



☞Photo: Friant-Kern Canal

This region receives runoff from four main river basins, the Kings, Kaweah, Tule and the Kern. The main flood control and regulatory reservoirs for these rivers are Pine Flat Lake, Lake Kaweah, Lake Success, and Lake Isabella. Major water conveyance facilities for the area include the joint State-federal San Luis Canal, the CVP's Friant-Kern Canal, and the Cross Valley Canal. The SWP provides water to several west-side contractors and to Kern County Water Agency. Water districts within the region have developed an extensive network of canals and pipelines to deliver these main water sources to the end users. The region has no natural outlet to the ocean. Flood waters from the Kings, Kaweah and Tule rivers drain into the Tulare Lake Bed. During severe flooding, waters reaching Fresno Slough can overflow a drainage divide and reach the San Joaquin River. Flood waters from the Kern River that are not diverted to the area's extensive recharge facilities or to the SWP's Kern River Intertie reach Buena Vista Lake Bed. Both Tulare Lake and Buena Vista lakebeds, formerly the region's drainage sinks, have been converted to agricultural use and now receive floodwaters only in wet years.

☞Photo: Buena Vista Lake (aerial photo) with aqueduct in view

Water Demands and Supplies

Table 8-16 shows regional water demands and supplies. Significant water shortages occur now in average years, and large shortages occur in drought years. (Shortages at a 1995 level of development in average water year conditions represent the region's 820 taf of groundwater overdraft and 50 taf of shortages in Westlands Water District's service area.)

Table 8-16. Tulare Lake Region Water Demands and Supplies (taf)

	1995		2020	
	Average	Drought	Average	Drought
Applied Water				
Urban	690	690	1,099	1,099
Agricultural	10,736	10,026	10,123	9,532
Environmental	1,752	827	1,771	846
Total Applied Water	13,178	11,543	12,992	11,476
Supplies				
Surface Water	7,968	3,711	7,871	3,611
Groundwater	4,340	5,970	4,386	5,999
Recycled and/or Desalted	0	0	0	0
Total Supplies	12,308	9,681	12,257	9,610
Shortages	870	1,862	735	1,866

☞Photo: Kern River Canyon

Under 1995 average hydrologic conditions, local surface supply from the Kings, Kaweah, Tule and Kern river systems are the most significant source of surface water to the region. The next largest surface water source is USBR's Central Valley Project, which delivers water through the joint State-federal San Luis Canal, Coalinga Canal, Friant-Kern Canal and Cross Valley Canal facilities. The only other major source of surface water is the State Water Project.

Of the Tulare Lake Region's SWP supply, the majority is contracted to Kern County Water Agency. KCWA's SWP supply is in turn distributed to its sixteen member agencies. The largest entitlements go to Wheeler Ridge-Maricopa Water Storage District, Berrenda Mesa Water District, Belridge Water Storage District, and Lost Hills Water District. Since these four districts have limited (or no) groundwater supply, each relies almost entirely on SWP supplies to meet its water demands. Most other KCWA member agencies have Kern River, Friant-Kern Canal, Cross Valley Canal or groundwater supplies available. Tulare Lake Basin Water Storage District and Dudley Ridge Water District are the next largest SWP contractors in the region. (Under provisions of the 1995 Monterey Agreement and Amendments, Kern County Water Agency and Dudley Ridge Water District, are permanently retiring 45,000 af of their annual SWP entitlements.)

The SWP's California Aqueduct assists in managing Kern River floodwaters at the Aqueduct's Kern River Intertie, constructed to allow Kern River flood waters to enter the California Aqueduct. The latest use of this structure to relieve flooding in Kern County was during the storms of January 1997. The Intertie may also be operated in reverse, to protect the Aqueduct from overtopping due to flood waters that enter the Aqueduct upstream of the Arroyo Pasajaro, Salt and Cantua Creeks. In 1995, for example, 15,000 af were allowed to discharge into the Kern River channel from the Aqueduct.

☞Photo: aerial photo of Tulare Lake (dry)

The Friant-Kern Canal conveys CVP supply to 24 long-term contractors in the region. Among the largest contractors of Friant-Kern Canal supply are Arvin-Edison Water Storage District, Lower Tule River Irrigation District, and Delano-Earlimart Irrigation District. The San Luis Canal also distributes CVP supply, most of which goes to Westlands Water District. With an allocation of 1,150,000 af, Westlands Water District is the largest CVP contractor. Westlands primarily delivers to agricultural users; however about 5,500 af is supplied to M&I users such as Lemoore Navel Air Station. (Even with a full CVP supply, Westlands must purchase about 200,000 af from other sources to meet normal crop needs.)

In 1974, Arvin-Edison Water Storage District and Kern County Water Agency entered into agreements for participation in the Cross Valley Canal. Arvin-Edison also entered into water exchange agreements with ten agencies in the Friant-Kern Canal service area. Delivery of the exchange water is made through the California Aqueduct and the Cross Valley Canal to Arvin-Edison's facilities. Arvin-Edison receives 128,300 af annually of exchange water and makes available to exchange entities the first 174,300 af of its Class I and Class II CVP entitlements from the Friant-Kern Canal.

☞Photo: Kern River Intertie

Average groundwater extraction (including extraction representing overdraft) is estimated to be about 5.2 maf in 2020 for the region. Since groundwater provides a buffer for fluctuating year-to-year surface supplies, its availability to the region is of great importance. Groundwater overdraft for the 1995 level supplies is estimated to be about 820,000 af, expected to decrease to 670,000 af by 2020 due to declining agricultural demands.

Local Water Resources Management Issues

Groundwater Overdraft

Groundwater levels in Tulare Lake Region normally rise each winter due to recharge from streams, sloughs, ponds, and irrigation of farmland. Urban use of groundwater is relatively constant year-round, but in the summer farmers and agricultural industries extract large amounts of groundwater to supplement their surface supplies, so groundwater levels decline. The extent of annual fluctuations in water levels is dependent on the availability of surface water. The Department's review of groundwater conditions in the region showed approximately 820,000 af of overdraft for the Tulare Lake at a region 1995 level of development for an average water year. About 70 percent of the region's overdraft occurs in the Kings-Kaweah-Tule Rivers planning subarea. Urban water demands in the subarea are met almost exclusively by pumping groundwater. Agricultural development in the subarea includes a large acreage of permanent crops (645,000 acres in 1995). In order to protect their investments, farmers with permanent crops will use groundwater to supplement local surface water supplies in drought years. Overdraft in the region is mitigated to a certain extent by planned recharge programs, over-irrigating crops in wet years, and allowing seepage from unlined canal systems. Although, CVP and SWP were intended to reduce groundwater overdraft in the region by providing a source of surface water to be used instead of groundwater, recent reductions in export supplies from the Delta, coupled with the recent drought have caused increased groundwater extraction in the region.

Land subsidence due to declining water levels is a concern in the Tulare Lake Region. Land subsidence due to groundwater withdrawals has occurred in varying degrees over parts of the western portion of the region. Since the cessation of a real subsidence monitoring programs in the 1970s, there has been little regional data collection on amounts and impacts of subsidence, although some facility specific monitoring has been performed (e.g., along the California Aqueduct). Many water districts and local farmers have noticed the lowering of bridges, canal embankments, and other structures that may be the results of increased groundwater extraction during recent drought years.

Groundwater Banking Programs

Semitropic Water Storage District is currently participating in an in-lieu groundwater banking project with MWDSC, SCVWD, and ACWD. This project involves expanding the Semitropic's conveyance system, so that areas normally relying on groundwater will have surface water available in above average water years. In these wet years Semitropic water users will receive excess surface water from re-regulating its banking partners' SWP supply. In drier years, Semitropic would release its SWP allocation to its partners and if necessary pump groundwater back into the California Aqueduct to meet its obligations. The maximum storage capacity of Semitropic's groundwater basin is 1 maf. Commitments have been made among MWDSC, SCVWD, and ACWD for 75 percent of the project. The remaining 25 percent or 250,000 af of storage is available to other potential banking partners.

MWDSC and Arvin-Edison Water Storage District are completing negotiations on a 350,000 af water banking/transfer program. Water banked in this program would be provided by both AEWSD and MWDSC. AEWSD would provide up to 150,000 af of its supplies to MWDSC, depending on the quantity of new water yield developed by the program. MWDSC will provide the remaining portion of the water supplies from its own sources. AEWSD will construct 500-600 acres of new infiltration basins, 15 new extraction wells, and a 4.5 mile pipeline intertie with the California Aqueduct.

Groundwater Quality

Though groundwater quality is important for all uses, it plays a pivotal role in meeting residential and industrial requirements. Most of the region's urban population relies on groundwater to meet its water demands. In the Fresno/Clovis area, dibromochloropropane (DBCP), a pesticide, and trichloroethylene (TCE), a solvent, have been the predominant contaminants found. The City of Fresno has recently approved the construction of a surface water treatment plant to supplement its groundwater supply. The plant will treat part of the City's San Joaquin and Kings rivers entitlements. The City of Mendota has had a long-standing salinity problem since the mid-1980's. Mendota's municipal water wells contain high TDS, chloride and sulfate levels. The City of Kerman has had a continuing uranium problem. The City of Rosedale (in Kern County), was forced to shut down 8 wells where nitrates, pesticides, and uranium contamination were found in the groundwater. Uranium has also been found in

wells southwest of the City of Bakersfield. Elevated levels of nitrates have been found in wells in the cities of Orange Cove, Shafter and Lindsay. The City of Hanford has found high levels of arsenic and sulfates in its water supply wells. A long-standing nitrate contamination problem in the McFarland area in Kern County is described in Chapter 5.

It is expected that SDWA source water protection requirements will increasingly drive efforts to prevent future groundwater contamination and to implement wellhead protection programs. The treatment technologies discussed in Chapter 5 will increasingly be needed to meet future urban demands in the region.

Agricultural Drainage

Large areas of the Tulare Lake Region's agriculturally rich west-side must contend with high groundwater tables. Typically, applied irrigation water builds up above semi-impervious clay layers and creates a shallow unconfined aquifer of generally poor to unusable quality. As the water tables rise and reach crop root zones, this water must be removed by subsurface drains or crop production will suffer. Until it was discovered in the 1980s that selenium and other constituents were causing waterfowl mortalities at Kesterson Reservoir, the predominant method of drainage disposal was in evaporation ponds. More farmers now rely on source control measures. The RWQCB has been involved in a lengthy regulatory process to establish the conditions under which evaporation ponds may still be used.

Arroyo Pasajero and Other Westside Cross-drainages

The Department, USBR, and U.S. Army Corps of Engineers are completing a 4-year feasibility study to identify a long-term solution to flooding and sedimentation problems threatening the California Aqueduct at its juncture with Arroyo Pasajero, an ephemeral stream. The Aqueduct was constructed across the Arroyo's alluvial fan and formed a barrier to the arroyo's flows, which carry a high sediment loading. As designed, Arroyo flows were to be impounded upslope of the Aqueduct in a 16,500 acre-foot ponding basin that included a culvert to route floodwaters east of the Aqueduct and inlet gates to discharge runoff into the Aqueduct. The original runoff estimates, based on the limited hydrologic and sediment loading data of the time, have proven to be about one-fourth of today's estimates. Long-term solutions currently under consideration involve a substantial increase in ponding capacity and significant efforts aimed at sediment management. The Department is also investigating a similar problem 20

miles north of the Arroyo Pasajero at the Cantua Creek Stream Group. This stream group, with a drainage area of approximately one-half the size of the Arroyo's creates similar flooding and water quality problems at the Aqueduct.

☞Photo: Arroyo Pasajaro flooding

Kings River Fishery Restoration Actions

Kings River Conservation District is cooperating with the USACE in a feasibility study of Kings River fishery habitat improvements associated with USACE's Pine Flat Dam. The study is to evaluate impacts of original project construction, riparian habitat restoration opportunities downstream of the dam, potential operating strategies to minimize lake level fluctuations during fish spawning periods, and temperature control methods for trout populations. One component of the study includes planning a new multi-level intake structure for the reservoir, to better manage downstream river temperatures. USACE is also performing a related project to install a turbine bypass pipe at the dam's powerplant, to allow releases through the existing penstocks when the turbines are not in operation, also to provide temperature control for the downstream trout fishery.

Water Management Options for the Tulare Lake Region

Table 8-17 shows a comprehensive list of options for the region. After initial screening, 10 local options were retained for further evaluation. Most of the retained local options involve conjunctive use or water transfers. The evaluation and scoring of retained options is shown in Table 8A-3 in Appendix 8A. The results are shown in Table 8-18.

Table 8-17. Comprehensive List of Options
Tulare Lake Region

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to 0.8 ET_0	Defer	No substantial depletion reductions attainable.
	Residential Indoor Water Use	Defer	No substantial depletion reductions attainable.
	Interior CII Water Use	Defer	No substantial depletion reductions attainable.
	Distribution System Losses	Defer	No substantial depletion reductions attainable.
Agricultural			
	Seasonal Application Efficiency Improvements	Retain	
	Flexible Water Delivery	Defer	Already highly developed; no substantial depletion reductions attainable.
	Canal Lining and Piping	Defer	No additional depletion reductions attainable.
	Tailwater Recovery	Defer	No additional depletion reductions attainable.
Modify Existing Reservoirs/Operations			
	Enlarge Pine Flat Dam	Retain	
	Enlarge Lake Kaweah (Terminus Dam)	Retain	
	Enlarge Success Lake	Defer	Flood control project; minimal water supply.
New Reservoirs/Conveyance Facilities			
	Rodgers Crossing Project	Defer	Segment of Kings River designated as a Special Management Area, under Wild and Scenic Rivers Act.
	Mill Creek Reservoir	Defer	Cost per acre-foot of water developed too high.
	Mid-Valley Canal	Defer	Questionable water supply availability. No longer viable as local option.
Groundwater/Conjunctive Use			
	City of Clovis Expansion of Recharge Facilities	Retain	
	Kaweah River Delta Corridor Enhancement Recharge	Defer	Minimal yield.
	Kern Water Bank as Component of SWP	Defer	Questionable water supply availability. No longer viable.
	Kern Water Bank Authority Recharge Facilities	Retain	
	Kern Delta Water District Recharge Facility	Retain	
	Buena Vista Water Storage District Water Banking Project	Retain	
	Cawelo Water District Water Banking Project	Retain	
Water Transfers/Banking/Exchange			
	SCVWD/Delta Mendota Authority	Retain	
	Westlands Water District	Defer	Sellers not yet identified.
Water Recycling			
	---	---	By definition in this Bulletin, does not generate new water.
Desalination			
Brackish Groundwater			
	Agricultural Drainage		High costs and lack of a clearly defined brine disposal alternative.
Seawater			
	---	---	---

Table 8-17. Comprehensive List of Options
Tulare Lake Region

Category	Option	Retain or Defer	Reason for Deferral
Other Local Options			
	---	---	---
Statewide Options			
	Westside Land Retirement	Retain	
	CALFED Bay-Delta Program	Retain	
	SWP Interim South Delta Program	Retain	
	SWP Supplemental Water Purchase Program	Retain	
	Drought Water Bank	Retain	
	Enlarge Shasta Lake	Retain	
	CVPIA Water Acquisition Program	Retain	

Water Conservation

Urban. Urban conservation options were deferred from evaluation because there is little potential to create new water (reduce depletions) from them in the Tulare Lake Region.

Agricultural. Improving irrigation scheduling would increase seasonal application efficiency to 76 percent, reducing depletions by less than 1 taf per year. System improvements including pressure regulation and filtration, along with better irrigation scheduling, would increase SAE to 78 percent and reduce depletions by 5 taf per year. To reach 80 percent SAE, conversion to more efficient irrigation systems would be needed, reducing depletions by 10 taf per year. Flexible water delivery is deferred because existing delivery system in the region are highly developed, and further improvements would add little depletion reductions at a high cost. Canal lining is deferred because areas in the region where lining and piping could reduce water depletions (the westside of the valley) have already had such improvements. Other areas in the region rely on unlined canals for in-lieu groundwater recharge. Tailwater recovery is deferred because of the extensive use of tail water recovery already occurring in the region.

Westlands Water District Distribution System

Westlands Water District is the CVP's single largest agricultural water contractor. Among central valley agricultural water districts, Westlands is unique both for its size (almost 1,000 square miles) and for its irrigation distribution system — which is based entirely on pipelines, rather than open canals. Altogether the distribution system has over 1,000 miles of buried pipe, varying in diameter from 10 to 96 inches. The basic design flow rate for each farm delivery system is one cfs per 80 acres.

Modifying Existing Reservoirs and New Reservoirs

Additional Storage in Kings River Basin. Pine Flat Dam on the Kings River, completed in 1954, is a USACE flood control project that also provides supplemental water supply to Kings River Basin water users. In 1974, the Kings River Conservation District commissioned preparation of a master plan to evaluate local solutions to continuing flood control and water supply problems. This study identified three potential projects to improve storage and regulate Kings River flows. These three projects ranked according to cost preference were:

(1) Enlargement of Pine Flat Dam

(2) Rodgers Crossing project

(3) Mill Creek project

In 1989, a USACE reconnaissance study investigated flood control and water related resource opportunities in the Kings River Basin. After an initial screening of several alternatives, including the three mentioned above, enlargement of Pine Flat Dam was retained for further study. An alternative for a 15 foot increase of gross pool height appeared to have the best benefit-to-cost ratio. This alternative would increase the reservoir's storage capacity about 92,800 af and provide an average of 12,700 af of additional yield per year. The major benefit would be reducing flood damages an estimated $2.7 million. Nevertheless, with a B/C ratio of 0.92 to 1, this alternative is not economically feasible at the time. The Rodgers Crossing project, entailing a proposed reservoir that would be located upstream of Pine Flat Dam, was rendered infeasible when the damsite was included in a river segment subsequently designated as wild and scenic.

Mill Creek is a small, uncontrolled, intermittent stream tributary to the Kings River below Pine Flat Dam. The Creek's small watershed (approximately 120 square miles), normally produces minor stream flows. However, heavy local rainstorm events occasionally result in flows in excess of 10,000 cubic feet per second, high enough to cause damage to the Kings River channel for many miles downstream. (The average annual discharge of the creek is approximately 30,000 af.) In the 1970s, the USACE studied the feasibility of constructing a dam on Mill Creek, just upstream of its confluence with the Kings River. The benefits of such a project would include additional flood protection, water conservation, power generation, and recreation. The proposed reservoir would have a capacity in excess of 600,000 af and would be

directly linked with Pine Flat Reservoir by a tunnel, allowing the reservoirs to be operated conjunctively. In wet years, Kings River water that would normally flood Tulare Lakebed could be diverted and stored in Mill Creek Reservoir. USACE's studies indicated that the cost per acre-foot of water developed would have been too high to justify the project.

Additional Storage in Kaweah River Basin. Lake Kaweah is located on the Kaweah River about 20 miles east of Visalia. Terminus Dam was completed in 1962 by the USACE to provide flood protection and irrigation water supply to downstream users. The Corps subsequently produced a draft feasibility report to investigate continuing flood control problems and water resource needs on the Kaweah River. The study identified three possible alternatives: increase storage of Lake Kaweah through the enlargement of Terminus Dam, construct a flood detention dam on Dry Creek above Lake Kaweah, or construct a reservoir on Dry Creek with a connecting tunnel to Lake Kaweah. Upon further study, only the enlargement of Terminus Dam was considered due to the extensive environmental and cultural impacts that would develop from construction of facilities on Dry Creek. Enlarging Terminus Dam would involve raising and enlarging the spillway, increasing average annual water supply storage in Lake Kaweah by 8,400 af through better regulation of flood flows. Congress authorized enlargement of Terminus Dam in the Water Resources Development Act of 1996. Construction is tentatively scheduled to begin in 2000 and to be completed in 2002. The Terminus Dam enlargement is projected to have a capital cost of about $37 million, most of which has been allocated to flood control.

☞Photo: existing Terminus Dam

Additional Storage in Tule River Basin. Tulare County and the Tule River Association requested that USACE consider providing additional storage in the basin by enlarging Success Lake, in response to flood protection problems experienced in a number of large storms (most recently, the January 1997 flood event in the Central Valley). It is estimated that Success Lake provides about a 55-year level of protection for the City of Porterville. A 1992 reconnaissance study found that a 10 foot increase in gross pool height with a corresponding increased storage capacity of 28,000 af was the preferred alternative. The 28,000 af enlargement would provide additional storage for irrigation water of 2,800 af. USACE entered into a feasibility cost-sharing agreement with the Lower Tule River ID for updating the 1992 study and for preparing an EIR/EIS. The draft feasibility study and EIR/EIS are scheduled to be released for public review

in 1998. The 1992 reconnaissance report estimated the capital cost to be about $23 million. Since the reservoir enlargement's primary purpose is flood control and only minimal water supply benefits are provided, the project is not considered further in this chapter as a future water supply option.

New Conveyance Facilities

This potential conveyance project, and the constraints on its implementation, were discussed in the San Joaquin River section. Due to significant reductions in the amount of water that can be expected from the Delta since the project's initial formulation, the project is not feasible at this time as a local option.

Groundwater and Conjunctive Use

Many local water districts and cities in the region, already utilize excess surface water allocations, purchased water, and floodwaters, when available, for groundwater recharge purposes. Local distribution systems, and CVP and SWP conveyance facilities create many opportunities for water supply agencies to exchange and purchase surface supplies for groundwater banking. Some parts of the region, such as the west side of the valley, however, are underlain by poor quality groundwater. Opportunities for groundwater banking or conjunctive use projects are limited in these areas. Possible groundwater recharge and conjunctive use options available to the Tulare Lake Region are discussed below.

The City of Clovis has an existing agreement with Fresno Irrigation District that entitles the city to an average of 13,805 af of Kings River water and 1,100 af of Class II water from Millerton Lake. Currently the city's surface water supply is exclusively used for groundwater recharge. Existing facilities can recharge approximately 7,800 af. As the city expands and acquires additional water rights, average annual surface supplies are expected to increase to 30,100 af by 2015. With this increase in supply, the city is actively pursuing new groundwater recharge sites to recharge an additional 10, 500 af per year.

Visalia plans to develop new groundwater wells as the community and water demands grow, estimating that 15 additional wells will be necessary to meet average year water demands in 2020. Visalia is also working with the Kaweah Delta Water Conservation District and Tulare County on a Kaweah River Delta corridor study to investigate sites for multiple use for groundwater recharge, floodwater management, and habitat restoration. The study is currently

in the feasibility stage, and has identified several potential sites. The project would include groundwater recharge basins with a storage capacity of about 750 af. A demonstration project has been proposed to model and further refine the integration of groundwater recharge, flood protection and habitat restoration.

In 1985 the Department, in cooperation with Kern County Water Agency and local water districts, began developing the Kern Water Bank conjunctive use program as a component of the SWP. The program would have allowed the Department to store water in above-average water years and withdraw it during dryer years. The Department purchased 20,000 acres of property overlying the Kern River alluvial fan for a direct recharge project known as the Kern Fan Element. However, subsequent regulatory actions affecting Delta exports made the Kern Water Bank less valuable as a source of SWP supply.

☞Photo: Kern Water Bank

Pursuant to Monterey Agreement contract amendments, Fan Element property is being transferred from the Department to the Kern Water Bank Authority, a JPA. The KWBA had been operating about 3,000 acres of recharge basins under an emergency CEQA exemption and an interim ESA Section 7 consultation. These temporary environmental permits has been issued to the Authority to allow it to recharge winter floodwaters. Since May 1995 the Authority has recharged about 450,000 af on behalf of its member agencies. The Kern Water Bank Authority prepared a 75-year habitat conservation plan/natural community conservation plan covering the use of the approximately 20,000-acre property. The HCP sets aside about 10,000 acres for habitat purposes. ESA listed species found in the project area include the kit fox, kangaroo rat, and blunt-nosed leopard lizard. The Authority plans to expand the recharge facility to as much as 6,400 acres. The cost for this expansion, including additional conveyance structures is estimated to be close to $30,000,000.

☞Photo: kit fox

An option for the Kern Delta Water District is to construct a groundwater recharge facility that would work in conjunction with the Kern Water Bank Authority's project. The proposal would involve constructing a ditch to convey Kern River water to a 320 acre parcel owned by the district.

Buena Vista Water Storage District is currently preparing a plan to construct as much as 200 acres of additional facilities to bank excess Kern River water. Buena Vista has an existing long-term exchange agreement with West Kern Water District. West Kern Water District exchanges its SWP water for BVWSD groundwater. This groundwater is the primary supply for the City of Taft. Much of the SWP exchange water is recharged in a 50 acre facility located several miles north-east of the city. The new facilities are estimated to cost about $250,000.

The Texaco Oil Company has recently entered into partnership with Cawelo Water District, located north of Bakersfield, to supply water that is released during its oil recovery process. A significant amount of water can be found trapped in oil bearing zones. The quality of much of this water is good, once it has been separated from the oil. The oil industry has historically used this water to recover additional oil by injecting steam or water into the oil bearing zones. The agreement struck by Texaco and CWD made possible the construction of an 8 mile pipeline to carry as much as 13,000 af/year of this water to the district. In addition to this new source of water, in 1996 the district purchased almost 90 acres of land straddling Poso Creek. To enhance groundwater recharge, the district will allow the land to be flooded during high flows. Work will begin shortly on a feasibility study that will address the district's long-term plans for more extensive recharge facilities.

Water Transfers

As described in Chapter 6, the San Luis and Delta-Mendota Water Authority has agreed with SCVWD and USBR to an internal reallocation of existing CVP supplies. Under this option, participating member agencies of SLDMWA can receive some of SCVWD's federal water allocation in normal and above-normal water years in exchange for the commitment to a share of their federal allocation during drought years. SCVWD would provide 100,000 af for reallocation within a 10-year period.

Westlands Water District has initiated a short-term buy-back program for water users who may be interested in selling any of their unused water allocation or other supply to the District. Even though the District is water short in most years, and purchases supplemental water from other sources, individual farmers in the District may have more water available than needed for their planned crop production. This program would occur only if the District had not finalized transfers from other sources to meet its total supplemental water needs. Transfers under this

program would be intra-regional transfers. WWD is currently preparing a draft programmatic EIR on purchasing and transferring up to 200,000 af of water to its service area. We have not included this program in our water management options evaluation because specific details for the proposed transfers are not yet available.

Water Marketing - WaterLink Program

In March 1996 the first electronic water marketing system went on-line in Westlands Water District. The WaterLink system was designed as a joint effort by the University of California Berkeley and Davis campuses, the Natural Heritage Institute, and farmers and water district staff. The project was funded by a grant from the Bureau of Reclamation. WaterLink allows district growers to use their home computers to post and read bids, access information on average prices and trading volumes, and negotiate transactions. WaterLink can also be used to schedule water deliveries and eventually to obtain water account balances, a feature that will enable water users to manage their water supplies more effectively. WaterLink is an intra-net system, available only to District growers, to allow them to make internal trades of in-District supplies.

Water Recycling

In the Tulare Lake Region, most municipal and industrial water use occurs on the east side of the San Joaquin Valley. The wastewater produced from urban and industrial use is generally recharged to groundwater basins. The magnitude of the region's groundwater overdraft, and the region's high level of groundwater use, make recharge of wastewater treatment effluent a logical water management action for the region. There are, however, no identified water recycling projects in the region that would qualify as new sources of supply.

Desalination

There have been many studies exploring the possibilities of reclaiming the saline groundwater on the west side of the San Joaquin Valley. The Department has been involved in three such studies: a wastewater treatment evaluation facility in Firebaugh, the Los Banos demonstration desalting facility, and the Adams Avenue agricultural drainage research center. There are many problems to overcome in developing a working system to collect the drainage water, treat it, distribute the fresh water, and dispose of the waste. These problems boil down to two main concerns -- the cost of producing fresh water and of disposal of the concentrated brine. The production cost for this water, about $1,000 per acre-foot, is too high for agriculturally based water districts. Furthermore, finding an acceptable location to dispose of the waste from such a facility is difficult. Until an affordable technology to desalt drainage water is developed, and a

solution to the disposal problem is found, desalting brackish groundwater in this region is unlikely.

Statewide Options

Active planning for statewide water supply options is being done currently for the CALFED Bay-Delta Program and for SWP future supply. See Chapter 6 for discussion on statewide demand reduction and water supply augmentation options. *[The following text on SWP supplies is a placeholder for potential outcomes of CALFED process. Text will be changed as CALFED results become available.]*

Land Retirement. Two land retirement options were evaluated as described in Chapter 6. Option 1, retiring 30,000 acres of agricultural lands with the worst drainage problems, would save about 65 taf of water per year. If Option 2 were implemented, up to 85,000 acres would be retired resulting in 185 taf per year of water savings.

CALFED Bay-Delta Program. Improving conditions in the Sacramento-San Joaquin River Delta would provide improvement to SWP and CVP supply reliability to the region. For illustrative purposes, assuming improved Delta conditions through the implementation of CALFED alternatives, additional SWP yield to the region could be 45,000 and 53,000 af in average and drought years, respectively. Additional CVP supply to the region could be 140,000 af and 165,000 for average and drought years.

State Water Project Improvements. DWR has two programs underway which would improve SWP yields to its contractors in the Tulare Lake region. The programs are discussed in Chapter 6. The ISDP would augment SWP supplies to the region by 35,000 af and 28,000 af in average and drought years, respectively. The Supplemental Water Purchase Program could provide an additional 64,000 af in drought years.

Drought Water Bank. Based on past experience with the Drought Water Bank, it is estimated that about 250,000 af of water would be available for allocation. Of this amount, past experience suggests that 54,000 af would be made available to the Tulare Lake Region.

Enlarged Shasta Lake. Enlarging Shasta Lake to 13 maf of storage would increase drought year yield by about 1.5 maf. If we assume one-third of this yield is allocated to the environment, and the remaining two-thirds is allocated among the State and federal projects, the region could potentially receive 445 taf and 525 taf in average and drought years, respectively.

CVPIA Water Acquisition Program. As discussed in Chapter 4, Alternative 4 was selected from among the CVPIA PEIS alternatives as a placeholder for Bulletin 160-98 future CVPIA environmental water demands because it represents the most conservative estimate of future water supply requirements. The PEIS estimates that 3,000 acres of irrigated agricultural land would be fallowed in the region to provide 15 taf per year for Level 4 wildlife refuge requirements.

Table 8-18. Options Evaluation Tulare Lake Region

Option	Rank	Cost per af ($)	Potential Gain (taf)	
			Avg	Drt
Conservation				
Agricultural				
Seasonal Application Efficiency Improvements (78%)	H	250	5	5
Seasonal Application Efficiency Improvements (80%)	M	450	10	10
Modify Existing Reservoirs/Operations				
Enlarge Pine Flat Dam	H	500	13	13
Enlarge Lake Kaweah (Terminus Dam)	H	*	8	8
Groundwater/Conjunctive Use				
City of Clovis Expansion of Recharge Facilities	H	440	--	11
Kern Water Bank Authority Recharge Facilities	H	95	--	339
Kern Delta Water District Recharge Facility	H	85	--	47
Buena Vista Water Storage District Water Banking Project	H	100	--	29
Cawelo Water District Water Banking Project	H	85	--	13
Water Transfers/Banking/Exchange				
SCVWD/Delta Mendota Authority	H	*	10	--
Statewide Options				
Westside Land Retirement (30,000 acres)	M	55	65	65
Westside Land Retirement (85,000 acres)	M	63	185	185
CALFED Bay-Delta Program	M		185	218
SWP Interim South Delta Program	M	100	35	28
SWP Supplemental Water Purchase Program	L	150	--	64
Drought Water Bank	H	175	--	54
Enlarge Shasta Lake	M		445	525
CVPIA Water Acquisition Program	M		15	15

* No data available.

Water Resources Management Plan for Tulare Lake Region

Water supplies are not available to meet all of the region's 2020 water demands in average or drought years. Shortages are forecasted to be 0.7 maf and 1.9 maf in average and drought years respectively. Table 8-19 summarizes options that can most likely be implemented by 2020 to relieve some of the shortages.

Improvements in agricultural irrigation demand management will likely occur over the entire region, although much of the region is already quite efficient in its agricultural water management. Areas where this will have the most effect will be where agricultural lands overlie shallow groundwater of poor quality. The west side of the valley will receive the most benefits from water conservation practices that improve irrigation management. These practices could reduce depletion by 10,000 af if system upgrades are employed to increase seasonal application efficiencies to 80 percent.

The region's 2020 water shortage due to groundwater overdraft is estimated to be 670,000 af. There are several plans to expand existing recharge facilities or to construct new ones. Groundwater banking will constitute the majority of the projects used to reduce water supply shortages. Sources for water banking and conjunctive use include water transfers, exchanges and direct purchases with outside agencies.

The region's local surface supplies have already been extensively developed and further development opportunities are limited. The modification of existing facilities through the enlargement of Lake Kaweah and Pine Flat Lake could produce about 21,100 af of additional yield for irrigation supply to local farmers.

Due primarily to environmental restrictions placed on Sacramento-San Joaquin Delta water diversions, the region has seen a decrease in its imported state and federal water supplies. This has forced the area to rely more on local surface water, groundwater, and water transfers. Long-term solutions to management of Delta waters and in regulatory requirements brought about by programs such as the CALFED Bay-Delta Program may increase supplies for Tulare Lake and statewide water users. Statewide options for the region will include a Delta fix, SWP improvements, and State drought water bank, which could provide 220 taf and 300 taf in average and drought years respectively. Demand reduction by retiring 30,000 acres of the worst drainage areas on the westside of the valley would save 65 taf per year. Even with these options, substantial storages remain in the region in average and drought years.

Table 8-19. Summary of Options Most Likely to be Implemented by 2020 Tulare Lake Region

Option	*Potential Gain (taf)*	
	Average	*Drought*
Shortage	**735**	**1,866**
Conservation	10	10
Modify Existing Reservoirs/Operations	21	21
New Reservoirs/Conveyance Facilities	--	--
Groundwater/Conjunctive Use	--	439
Water Transfers/Banking/Exchange	10	--
Recycling	--	--
Desalination	--	--
Statewide Options	285	365
Total Potential Gain	326	835
Remaining Shortage	**409**	**1,031**

Chapter 9. Options for Meeting Future Water Needs in Eastern Sierra and Colorado River Regions of California

This chapter covers the hydrologic regions in the eastern sierra, North Lahontan and South Lahontan, and the Colorado River hydrologic region (Figure 9-1). These regions constitute 33 percent of the State's land area and are generally the least populated, with population totaling about 1.3 million in 1995.

North Lahontan Hydrologic Region

Description of the Area

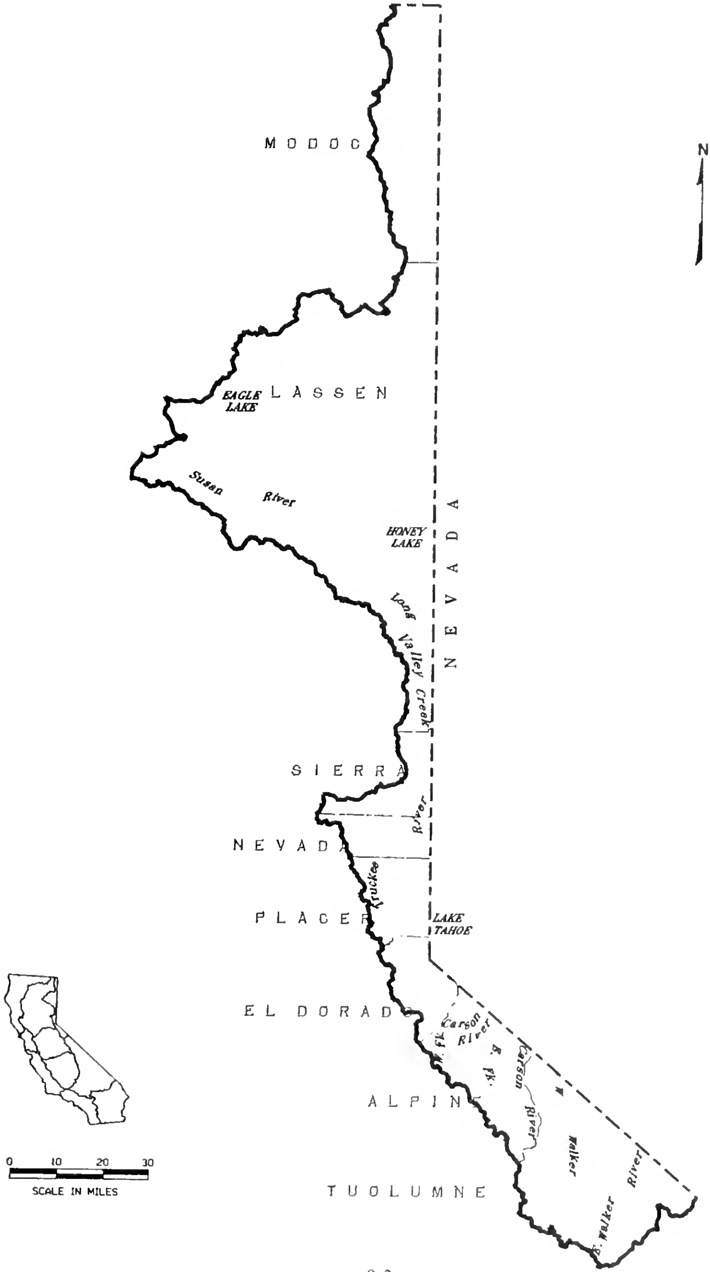
The North Lahontan Hydrologic region has two planning subareas (Figure 9-2), Lassen and Alpine. The Lassen Group Planning Subarea encompasses the northern North Lahontan Region within Lassen and Modoc counties. Lassen PSA is an arid, high desert with relatively flat valley areas adjacent to or interspersed with mountains. Valley elevations are about 4,000 and 4,500 feet for Honey Lake and Surprise valleys, respectively. The Warner Mountains, which form the western boundary of Surprise Valley, range in elevation from about 7,000 to more than 9,000 feet. Annual precipitation ranges from as little as 4 inches in Surprise Valley in Modoc County, to over 50 inches in the mountains of the Susan River watershed in Lassen County.

The Alpine Group Planning Subarea encompasses the southern part of the North Lahontan region within Sierra, Nevada, Placer, El Dorado, Alpine, and Mono counties. The subarea includes Lake Tahoe as well as the Truckee, Carson, and Walker river drainages. The rivers originate at high elevations on the eastern slopes of the Sierras and flow to terminal lakes or desert sinks in Nevada. Annual precipitation ranges from 8 inches in the valleys to more than 70 inches in the Sierras (much of this amount is snow).

The Lassen Group PSA is rural and sparsely populated. The City of Susanville is the largest population center in the subarea. In the Alpine PSA, more than 90 percent of the population lives in the Lake Tahoe and Truckee River basins. The City of South Lake Tahoe and Town of Truckee are the largest communities in the subarea. The Tahoe-Truckee region has many part-time residents and visitors during the summer and winter recreational seasons, reflecting the importance of tourism to the area. Tourism and related recreational opportunities are a vital force in the region's economy and for much of the region's service-sector employment.

Figure 9-1. Eastern Sierra and Colorado River Hydrologic Regions

Figure 9-2. North Lahontan Hydrologic Region



Cattle ranching is the main land use in the Lassen PSA. Irrigated land acreage is small (less than 4 percent of the region's land area). Commercial crop production is limited because of the short growing season. Pasture and alfalfa are the dominant irrigated crops. About 75 percent of the irrigated land is in Modoc and Lassen counties, and most of the remainder is in the Carson and Walker river valleys in Alpine and Mono counties. The irrigated land in the Carson and Walker river valleys is almost exclusively pasture at elevations above 5,000 feet. Most of the uplands areas are federally owned and largely managed as national forest land. Table 9-1 shows the population and crop acreage for the region.

Table 9-1. Population and Crop Acreage (in thousands)

	1995	2020
Population	84	125
Irrigated Crop Acres	161	165

Water Demands and Supplies

The water budget for the North Lahontan region is shown in Table 9-2. Agricultural water demands are generally met with local surface water supplies, when available. Throughout the northern portions of the region, runoff is typically scant and stream flow decreases rapidly during the irrigation season after the snowpack melts in the higher elevations. The amount of acreage irrigated for pasture and alfalfa is constrained by available water supplies.

No major changes in North Lahontan Region water use are anticipated during the Bulletin's planning horizon. Irrigated agriculture is already constrained by climate and by economically available water supplies. A small amount of agricultural expansion is expected, but only in areas that can support minor additional groundwater development. Likewise, the modest need for additional municipal supplies can be met by expanding present surface systems or increasing groundwater use. Drought year shortages are caused by a reduction in surface water supplies for agriculture and an increase in unit crop irrigation requirements for pasture and alfalfa. To calculate shortages, the water budget assumes that crop acreages under drought

conditions remain the same as under average conditions. Except for possible shortages in small mountain communities, no urban water shortages are forecast.

The majority of the water supply for the city of Susanville comes from groundwater and from Cady and Bagwell springs. The city has not experienced any water supply shortages nor does it expect any shortages for the next 20 years.

Table 9-2. North Lahontan Region Water Demands and Supplies (taf)

	1995		2020	
	Average	Drought	Average	Drought
Applied Water				
Urban	39	40	50	51
Agricultural	530	584	536	594
Environmental	635	341	635	341
Total Applied Water	**1,203**	**965**	**1,221**	**986**
Supplies				
Surface Water	1,038	642	1,020	642
Groundwater	157	187	183	208
Recycled and/or Desalted	8	8	8	8
Total Supplies	1,203	837	1,211	858
Shortages	0	128	10	128

The Honey Lake Valley Groundwater Basin is an interstate groundwater basin; the California portion of the basin is about 45 miles long and 10 to 15 miles wide. Groundwater extracted from the basin is used mainly for agriculture with a smaller portion used for municipal supply and refuse water supply at Honey Lake Wildlife Area. Groundwater use in the basin appears to be near the basin's perennial yield. A 1987 agreement among the Department, the State of Nevada, and USGS resulted in a study of the groundwater flow system in eastern Honey Lake Valley. Upon conclusion of the study in 1990, the Nevada State Engineer ruled that only about 13,000 acre-feet could be safely transferred from Nevada's portion of the basin for proposed new water development for Washoe County in Nevada. The Nevada out-of-basin transfer project has not gone forward.

The 7,840 acre Honey Lake Wildlife Area is on the north edge of Honey Lake about 20 miles southeast of Susanville. The HLWA is comprised primarily of intensively managed wetlands, crop lands, and native uplands adjacent to the 60,000 acre Honey Lake. It provides important habitat for migratory waterfowl, sandhill cranes, and other wetland species along the Pacific Flyway. During the irrigation season, most of the appropriated water for HLWA comes from the watershed of Willow Creek and its tributaries. HLWA has adjudicated water rights, administered by the Department, as determined in the 1940 Susan River Decree. Groundwater at the HLWA is used to irrigate crops, to flood and maintain wetlands as well as for domestic purposes.

The Truckee River originates above Lake Tahoe, and its flow is controlled by a small dam on the lake's outlet. The river flows through northeastern California and northwestern Nevada, and ultimately terminates in Pyramid Lake, which is located entirely within the Pyramid Lake Indian Reservation in Nevada. In addition to Lake Tahoe, water is stored in Martis Creek, Prosser Creek, Boca, and Stampede reservoirs, and in Independence Lake and Donner Lake. Table 9-3 shows the statistics for these reservoirs.

Table 9-3. Statistics for Major Reservoirs on the Truckee River in California

Reservoir Name	Dam Owner	Dam Operator	Usable Storage Capacity (af)	Dam Construction Date[1]	Dam Height (Feet)	Drainage Area (Square Miles)
Lake Tahoe	Sierra Pacific Power Company[2]	Truckee-Carson Irrigation District	744,600	1913	18	506
Donner Lake	Sierra Pacific Power Company/ Truckee-Carson Irrigation Dist.	Sierra Pacific Power Company	9,500	1930s	14	14
Martis Creek	USACE	USACE	20,400[3]	1971	113	40
Prosser Creek	USBR	USBR	29,800	1962	163	50
Independence Lake	Sierra Pacific Power Company	Sierra Pacific Power Company	17,500	1939	31	8
Stampede Reservoir	USBR	USBR	226,500	1970	239	136
Boca Reservoir	USBR	Washoe County Water Conservation Dist.	41,100	1937	116	172

[1] Date existing dam was completed.
[2] The U.S. Bureau of Reclamation controls the dam under easement from Sierra Pacific Power Company.
[3] Flood control storage only.

Most of the water supply developed by these Truckee River Basin reservoirs is used in Nevada to meet urban demands in the Reno/Sparks area; hydropower and irrigation demands; and fish and wildlife requirements relating to the lower Truckee River in Nevada and in Pyramid Lake. On average, about one-third of the Truckee River's annual flow is diverted through the Truckee Canal in Nevada to irrigate land in the Carson Division of USBR's Newlands Project, near Fallon, Nevada.

Truckee River operations have evolved in response to litigation, negotiation, court decrees, agreements, and legislation. The Truckee River General Electric Decree of 1915 and the Truckee River Agreement of 1935 form the basis of current river operations. The Orr Ditch Decree of 1944 established individual water rights in Nevada and, by incorporating the Truckee River Agreement, provided the guidelines for operating the federal reservoirs to serve those rights.

Modification of Truckee River operations occurred when two Pyramid Lake fishes, the cui-ui and lahontan cutthroat trout, were listed under the ESA. Stampede Reservoir was

constructed in 1970 by USBR to serve irrigation and municipal uses; as a result of litigation, a 1982 federal court decision required all storage in Stampede Reservoir to be used to provide water for the listed Pyramid Lake fish. Proposed changes in Truckee River operations are described in the following water management issues section.

In the Truckee basin within California, most of the urban demand occurs in and around the area's recently incorporated city (named the Town of Truckee) and is supplied from groundwater. The Martis Valley groundwater basin is the principal source for the nearly all water supplies. The areas of Northstar, Squaw Valley, and Glenshire utilize groundwater from smaller groundwater basins or from fractured rock sources. The developed area around Donner Lake is served by surface water. Truckee receives most of its water from Truckee Donner PUD. TDPUD is the largest purveyor in the basin, accounting for about half of the water delivered to commercial and residential customers.

Future water demands in the Truckee Basin are not expected to exceed the interstate allocations contained in PL 101-618 (discussed in the following section) that would, when they become effective, limit the basin's annual use to 32 taf.

☞Photo: Lake Tahoe Dam

On the California side of the Lake Tahoe basin, South Tahoe PUD, Tahoe City PUD, and North Tahoe PUD account for most of the water delivered to urban users. Water is supplied from the lake and from groundwater sources. The interstate allocation for California's Tahoe Basin in PL 101-618 would limit future water use in the basin to 23 taf of gross diversions. Estimated future water needs at full development were used as the basis for negotiating the interstate allocation. Future development in the Tahoe Basin is strictly limited by the bi-state Tahoe Regional Planning Agency to protect the basin's environmental quality. In both the Truckee and Tahoe basins, water use for snowmaking at the area's ski resorts has been considered within the interstate allocations.

Urban development in the Carson and Walker river basins is minimal and is clustered around the towns of Markleeville in Alpine County and Bridgeport in Mono County. More than 90 percent of the watershed on the California side is federally owned, primarily under the management of the Toiyabe National Forest. Groundwater is the source of supply for individual

users and small community systems located in valley areas. In the upper watershed however, communities may lack suitable sites to locate wells and therefore must depend on surface water sources. The Town of Markleeville depends on surface water and experienced a water shortage in 1989 when the stream that supplies the community went dry. Water had to be piped 4 miles from another creek to the town's treatment plant.

In the upper Carson River watershed, water is stored in several very small alpine reservoirs originally constructed to serve water for irrigating pasture and other agricultural purposes. Much of this water is used downstream in Nevada. The largest of the alpine reservoirs is Heenan Lake on Monitor Creek, tributary to the East Fork Carson River, with a capacity of nearly 3,000 af. Although the reservoirs still serve primarily agricultural uses, the Carson River supports a popular recreational trout fishery in the upper watershed. DFG has used Heenan Lake for raising Lahontan cutthroat trout to stock at other locations throughout the Sierras. DFG currently manages state-owned lands adjacent to Heenan Lake and has arranged to purchase water on an annual basis to maintain a minimum reservoir pool for fish rearing.

Two special-purpose reservoirs were constructed in the upper Carson watershed to receive treated effluent exported from South Tahoe PUD in the Lake Tahoe Basin. (Disposal of treated wastewater within the Lake Tahoe Basin has been banned to help protect the lake's clarity.) The export began in the 1960s, when the water was delivered to Indian Creek Reservoir. The water was then delivered from the reservoir to agricultural users for a supplemental irrigation supply. Harvey Place Reservoir, also constructed by South Tahoe PUD, became operational in 1989. Effluent exports of about 5,000 af now go to Harvey Place Reservoir, and Indian Creek Reservoir is used for freshwater recreation.

The Walker River watershed has several very small reservoirs in the upper watershed in addition to two large reservoirs --Topaz Reservoir, an offstream storage facility on the West Walker, and Bridgeport Reservoir on the East Walker. Both of the large reservoirs were built by Walker River Irrigation District to sustain summer irrigation flows to the service areas downstream in Nevada. WRID holds California water rights to store 57,580 af of West Walker water, plus 200 af of local inflow, in Topaz Reservoir. In Bridgeport Reservoir, WRID can store up to 39,700 af. SWRCB has established instream flow and minimum reservoir pool

requirements at Bridgeport, as in response to fish kills that occurred during the last drought. Both reservoirs are popular local recreational destinations; because of their proximity to Highway 395.

Part of the East Fork Carson River -- approximately 10 miles from the town of Markleeville to the California/Nevada state line -- has been added to the California wild and scenic river system. On the West Walker River, the California wild and scenic river system includes approximately 37 river miles from Tower Lake, at the headwaters, downstream to the confluence with Rock Creek, as well as about 1 mile of Leavitt Creek.

As occurred with the Truckee River Basin, water right disputes in the Carson and Walker river basins were settled with federal court decrees. The 1980 Alpine Decree on the Carson River and the 1936 Decree C-125 on the Walker River are the chief regulatory control of river operations today. The decrees established the surface water rights, including reservoir storage rights, of parties in both California and Nevada in each of the lawsuits. However, the decrees only quantify individual water rights of parties to the litigation and did not address rights perfected under state law for persons who are not successors in interest to parties holding decreed rights. Not all existing water users are necessarily covered in the decrees. In the Carson River Basin, however, PL 101-618 would, when its provisions take effect, establish an interstate allocation. The California allocation corresponds to existing basin water uses.

Local Water Resources Management Issues

Truckee River Operating Agreement.

Negotiation of a proposed Truckee River Operating Agreement, and preparation of its draft Environmental Impact Statement /Environmental Impact Report have been the major water management activity in the region. A draft EIS/EIR has been in preparation for several years, and expected to be released in 1998. A new operating agreement for the Truckee River is required under the Truckee-Carson-Pyramid Lake Water Rights Settlement Act (PL 101-618) enacted by Congress in 1990. The Act settled years of disputes over the water in the Truckee and Carson rivers by making an interstate water allocation between California and Nevada. It also settled certain Native American water right claims, and provided for water supplies for specified environmental purposes in Nevada. The Act allocates 23 taf annually in the Lake Tahoe Basin;

32 taf annually in the Truckee River Basin below Lake Tahoe; and water corresponding to existing water uses in the Carson River Basin, to California, with the rest of the Truckee-Carson River supply going to Nevada.

☞Photo: Donner Lake

The proposed TROA would establish procedures for river operations to meet water rights on the Truckee River while enhancing spawning flows in the lower Truckee River for cui-ui and Lahontan cutthroat trout. TROA would provide for management of water within the Truckee Basin in California, including instream flows and reservoir storage for fish and recreation uses. The agreement would include procedures for coordinating scheduled releases and exchanges of water among Truckee watershed reservoirs. TROA would become the exclusive federal regulation governing releases of water stored in Lake Tahoe, Martis Creek, Prosser Creek, Stampede, and Boca reservoirs. The agreement would address California's allocation of water in the Truckee Basin by providing an accounting procedure for surface and groundwater diversions, including allocations for snow-making; and would establish criteria to minimize short term reductions in river flow potentially caused by wells that might be constructed near the river in the future. In 1993, an agreement was signed among the Sierra Pacific Power Company, Washoe County Water Conservation District, and the Sierra Valley Water Company which settled a dispute about when the water company was required to stop diverting water from the Little Truckee River. This agreement, which resolves disputes that often occur during droughts, is being incorporated into the TROA.

Walker River

Recent activities on the Walker River have focused on the declining levels of Walker Lake in Nevada and the resulting impact on the lake's fishery. Over the years, upstream agricultural diversions have caused a decline in lake levels and increased its salinity. If the trend continues, the Lahontan cutthroat trout and the tui chub (an important food source for the trout) may no longer be able to survive in the lake. A solution to Walker Lake problems could have impacts to water users and water rights in California and Nevada. There are also potential tribal water rights claims in the Nevada side of the basin that could impact existing water rights.

☞Photo: Walker Lake

Lake Tahoe

Lake Tahoe's clarity has been declining, as increasing development around the shoreline increases the sediment load and nutrients reaching the lake. Nutrients such as nitrogen and phosphorous used in lawn or golf course fertilizers may enter the lake in the form of storm water runoff; these nutrients promote growth of algae, which in turn reduces clarity. Clarity of lakes is measured by the depth to which a Secchi disk, a small plastic disk of specific size, is visible. In the late 1960s, average annual Secchi disk visibility was on the order of 100 feet; now, some 30 years later, the figure is closer to 70 feet.

Efforts to improve Lake Tahoe water quality include programs implemented at the federal, state, and local level to regulate development and prevent pollutants from reaching the lake. The Tahoe Regional Planning Agency, a bistate agency created by Congress, sets regional environmental standards, issues land use permits including conditions to protect water quality, and takes enforcement actions on both the California and the Nevada side of the basin. TRPA's regional plan provides for the achievement and maintenance of adopted environmental threshold carrying capacities while managing growth and development. In addition to its regulatory activities, TRPA carries out a capital improvement program designed to repair the environmental damage done before the regional plan was adopted. TRPA has identified nearly $500 million in capital improvements needed to achieve the environmental threshold standards. Federal, state, and local governments have invested nearly $90 million dollars in soil erosion control, storm water drainage, stream zone restoration, public transit, and other capital projects. Since over 70 percent of the land in the Tahoe Basin is controlled by the USFS, Lake Tahoe Basin Management Unit, a major emphasis of the LTBMU watershed management plan is water quality protection. The LTBMU implements an ongoing watershed restoration program and implements a land acquisition program to prevent development of sensitive private lands.

In recent years, federal and state agencies have increased funding to protect the environment of Lake Tahoe. The federal government has budgeted $26 million over two years for environmental restoration. The state of Nevada approved a $20 million bond measure to perform erosion control and other measures on the east side of the lake while in California the passage of Proposition 204 will provide $10 million in bond funds for land acquisition and

improvement programs in the Tahoe Basin to control soil erosion, restore watersheds, or preserve environmentally sensitive lands.

Leviathan Mine

Leviathan Mine, an abandoned sulfur mine located in Alpine County, is one of the most significant abandoned mine sites in the region. From 1863 to 1952, operations at the site involved tunnel mining, which had minimal impact on nearby surface waters. Later, the site was converted to an open-pit operation, and tailings and overburden material were placed in or eroded into streams that drain the workings, creating water pollution problems with acid mine drainage and metals. In 1980, the SWRCB approved a pollution abatement project for the Leviathan Mine. The remediation project included channeling Leviathan Creek; filling and regrading the mine pit; excavating and regrading the waste dump; creating onsite evaporation ponds; regrading the spoil area; and improving drainage. The State acquired the site in 1983 and the project was completed in 1985. Although the project reduced the amount of AMD reaching the creek, contamination problems still occur today from pond overflows, acidic springs, seepage, and erosion. The RWQCB is currently involved in activities to further manage AMD.

Sierra Nevada Ecosystem Project.

The Sierra Nevada Ecosystem Project is a recent assessment of forests, key watersheds, and significant natural areas on federal lands. In 1996, the University of California released the *Sierra Nevada Ecosystem Study*, the result of a three year, congressionally-mandated study of the entire Sierra Nevada, with a primary emphasis on gathering and analyzing data to assist Congress and other decision makers in future management of the mountain range. The project's goal is to maintain the health and sustainability of the ecosystem, while providing resources to meet human needs. The study states that "excluding the hard-to-quantify public good value of flood control and reservoir-based recreation, the hydroelectric generating, irrigation, and urban use values of water are far greater than the combined value of all other commodities produced in the Sierra Nevada." The report estimates the value of water at 60 percent of all commodities produced in the foothills and mountains of the Sierra Nevada.

January 1997 Flood Event

The January 1997 flood event in the North Lahontan Region was one of the most significant floods on record within the region. The flood event was a rain-on-snow and rain-on-saturated soils flood event, worsened by the warmth of the tropical rain system. Lake Tahoe recorded its highest level since 1917 at an elevation of 6,229.39 feet. This elevation was the lake's highest since the 1935 Truckee River Agreement, which limited the range of Lake Tahoe's surface elevation to between 6,223.0 feet (its natural rim) and 6,229.1 feet. Flood damage occurred along the Truckee's channel immediately downstream from the lake, although the greatest economic damages occurred in the Reno-Sparks area. In California, flooding in downtown Truckee caused the closure of major highways. Downstream from Truckee, the river washed away Floriston Dam, a diversion dam used by Sierra Pacific Power Company to divert water to its run-of-river hydroelectric plant at Farad.

Stream flows along the Carson and Walker river systems exceeded previous flood records. Flows along the East Fork Carson River at Markleeville and West Fork Carson River at Woodsford peaked at 21,000 cfs and 8,000 cfs, respectively, considerably above the record peak flows attained in 1963 and in excess of a 100-year flood event for these reaches of the river. The East Walker River near Bridgeport and West Walker River near Coleville peaked at 1810 cfs, and 6220 cfs, respectively, also above previously record flows. In Mono County, about 8 miles of U.S. Highway 395 were washed out, isolating the communities of Coleville and Walker. At the lower mouth of the Walker Canyon, the community of Walker received damage to homes and property when the West Walker River spilled its banks.

Water Management Options for the North Lahontan Region

Table 9-4 shows a list of options being considered to meeting agricultural shortages in the North Lahontan region. Potential options to augment water supplies during drought conditions are water conservation, pumping groundwater, and building new reservoirs. Land fallowing or temporarily idling land during droughts is practiced when no other feasible alternative for eliminating water supply shortages exists. In Mono County, cutbacks in surface water deliveries during the recent drought resulted in pasture being fallowed to accommodate deficiencies.

Water Conservation

Urban. Urban conservation options were deferred from evaluation because there is little potential to create new water (reduce depletions) from them in the North Lahontan region.

Agricultural. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. The efficiency of border irrigation systems used for alfalfa and pasture can be improved through leveling fields and applying water efficiently. However, no significant depletion reductions are expected in the region, since most alfalfa irrigation occurs in Honey Lake Valley and exeess applied irrigation water recharges the groundwater basin. From a regional perspective, it appears that no significant depletion savings can be achieved.

Table 9-4. North Lahontan Region Comprehensive List of Options

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to 0.8ETo	Defer	No substantial depletion reductions attainable
	Residential Indoor Water Use	Defer	No substantial depletion reductions attainable
	Interior CII Water Use	Defer	No substantial depletion reductions attainable
	Distribution system Losses	Defer	No substantial depletion reductions attainable
Agricultural			
	Seasonal Application Efficiency Improvements	Defer	No substantial depletion reductions attainable
	Flexible Water Delivery	Defer	No substantial depletion reductions attainable
	Canal Lining and Piping	Defer	No substantial depletion reductions attainable
	Tailwater Recovery	Defer	No substantial depletion reductions attainable
Modifying Existing Reservoirs/Operations			
	---	---	---
New Reservoirs/Conveyance Facilities			
	Petes Valley Reservoir	Defer	High costs
	Willard Creek Reservoir	Defer	High costs
	Goat Mountain Reservoir	Defer	High costs
	Crazy Harry Gulch Reservoir	Defer	High costs
	Honey Lake Dike and Reservoir	Defer	Water quality inadequate for agriculture. Very low yields with large estimated capital costs.
	Long Valley Creek Reservoir	Defer	Very little firm yield.
	Hope Valley Reservoir	Defer	High costs
	Leavitt Meadows Reservoir	Defer	Site is located on the West Walker River, upstream of a reach designated under the Calif Wild and Scenic River Act. Also subject to interstate water issues with Nevada.
	Pickle Meadow Reservoir	Defer	Same concerns as Leavitt Meadows site.
	Roolane Reservoir	Defer	Same concerns as Leavitt Meadows site.
	Mountain Lakes Reservoir	Defer	Same concerns as Leavitt Meadows site.
Groundwater/Conjunctive Use			
	Agricultural Groundwater Development	Retain	
	Eastside Warner Mountain Recharge	Defer	DFG concerns about potential impacts to the Sand Hill Crane, brine shrimp, waterfowl, shorebirds, and regional deer herds have diminished local interest in a pilot program and/or reconnaissance level planning study.

Table 9-4. North Lahontan Region Comprehensive List of Options (cont.)

Water Transfers/Banking/Exchange			
	---	---	---
Water Recycling			
	---	---	---
Desalination Brackish Groundwater			
	---	---	---
Seawater			
	---	---	---
Other Local Options			
	---	---	---
Statewide Options			
	---	---	---

New Reservoirs

Potential reservoir sites identified in studies by federal, State, and local agencies are included in the comprehensive list of options for this region (Table 9-4).

In 1992, DWR investigated six potential reservoir sites in Lassen County that could provide storage of up to 20 taf. Sites were investigated on the Susan River, and Willow and Long Valley creeks. An analysis of project costs indicates that the reservoirs are not economically feasible for agricultural water users in the region.

DWR studies in late 1950s and early 1960s examined potential reservoir sites in Mono County that could serve agricultural lands in California. USBR, USGS, NRCS, and WRID have studied these and other potential sites in California which could provide water for Nevada uses. Projects which would provide water only to Nevada are not included here as options. The four potential sites in Mono County are located on the West Walker River and have similar economic constraints as the sites in Lassen County. They are also subject to interstate water rights concerns.

Groundwater

Although groundwater is a available in most agricultural areas, water needs are usually met from local surface water. Even during a drought, groundwater cannot be used economically to replace cutbacks in surface water deliveries because of high pumping costs to irrigate pasture.

Modoc County Resources Conservation District investigated groundwater recharge on six creeks which drain to the east of the Warner Mountains in Surprise Valley. This project would recharge the alluvial fans using existing stream channels or constructed recharge facilities. Experimental construction of recharge areas on one or two of the creeks was proposed, but potential environmental impacts and lack of funding prevented implementation. This option was deferred.

Water Resources Management Plan for the North Lahontan Region

All but one of the options were deferred from further evaluation because of economic or environmental reasons, or both (see Table 9A in Appendix 9A). Table 9-5 shows the ranking of the retained option. Although groundwater is available to eliminate surface water deficiencies during droughts, it is not highly ranked due to its cost. As a result, there are no options that would eliminate the drought year shortages. During droughts, pasture irrigation will probably be curtailed.

Table 9-5. North Lahontan Region Options Evaluation

Option	*Rank*	*Cost per af ($)*	*Potential Gain (taf)*	
			Avg	*Drt*
Groundwater/Conjunctive Use				
Agricultural Groundwater Development	M		♦	♦

♦ Data not available to quantify. Additional production potential is not great.

Table 9-6. Summary of Options Most Likely to be Implemented by 2020 North Lahontan Region

Option	Potential Gain (taf)	
	Avg	Drt
Shortage*	*10*	*128*
Conservation	-	-
Modify Existing Reservoirs/Operations	-	-
New Reservoirs/Conveyance Facilities	-	-
Groundwater/Conjunctive Use	-	-
Water Transfers/Banking/Exchange	-	-
Recycling	-	-
Desalination	-	-
Statewide Options	-	-
No options were quantified for this region.	-	-
Remaining Shortage	*10*	*128*

* Majority of shortages in this region are agricultural.

South Lahontan Hydrologic Region

Description of the Area

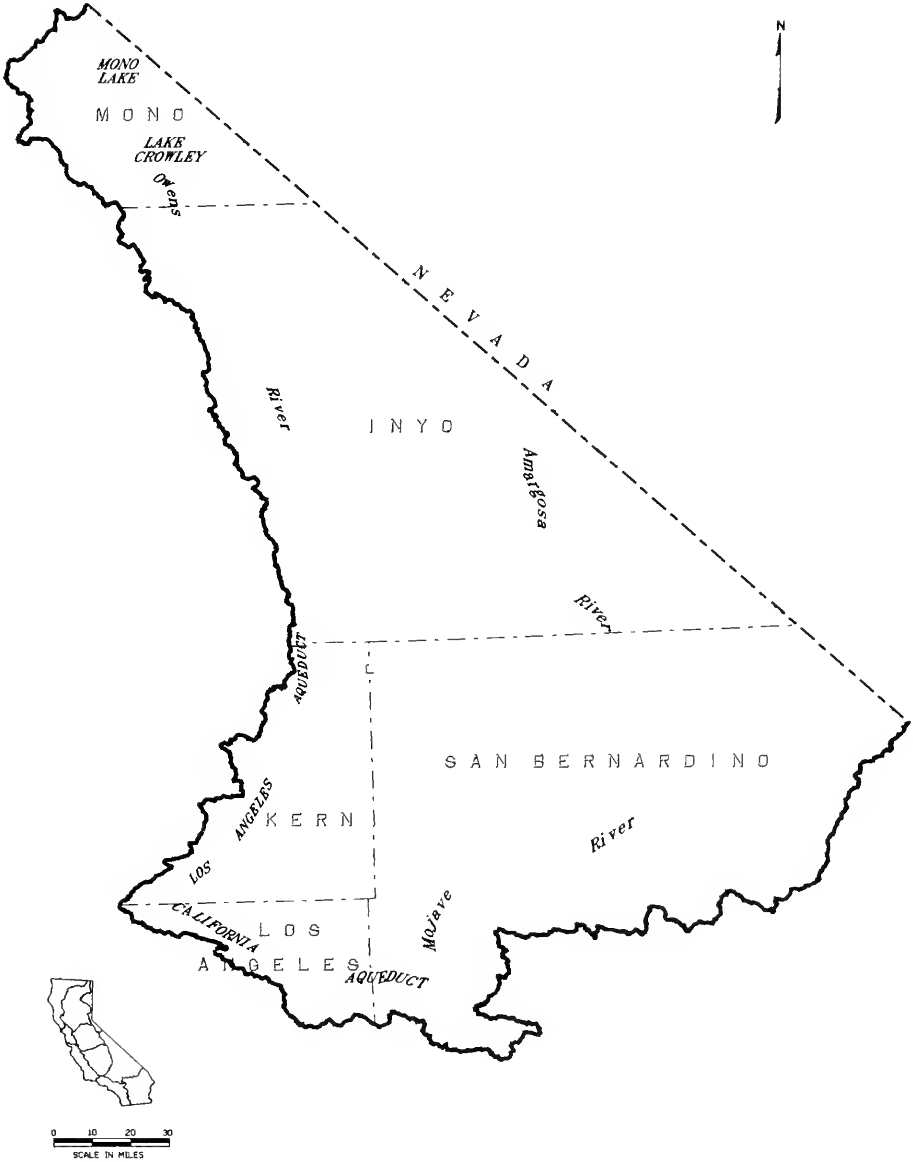
The South Lahontan Region encompasses the area from the mountain divide north of Mono Lake to the divide south of the Mojave River, encompassing much of the Mojave River (see Figure 9-3). The region is bordered on the east by the Nevada state line and on the west by the crest of the southern Sierra Nevada and San Gabriel mountains. The region includes all of Inyo County and parts of Mono, San Bernardino, Kern, and Los Angeles counties. Prominent geographic features of the region are Owens Valley and Death Valley. The region contains the highest and lowest points in the lower 48 states -- Mount Whitney (elevation 14,495 feet) and Death Valley (elevation 282 feet below mean sea level).

The region is a closed drainage basin with many desert valleys that contain central playas, or dry lakes, especially in the western Mojave Desert. Major waterbodies in the region are, from north to south, Mono Lake, Owens River, and Mojave River. The Amargosa River, which drains Death Valley and adjoining areas (including a portion of Nevada), contains water only during rare flash floods. Any floodwaters in the Amargosa River would eventually flow south to a sink area at the Silver Lake and Soda Lake playas. This sink area is also the terminus of the Mojave River, which flows eastward from its headwaters in the San Bernardino Mountains across the Mojave Desert to the playa lakes.

☞Photo: Joshua tree

Average annual precipitation for the region's valleys ranges between 4 and 10 inches. Variations above and below this range do occur; for example, Death Valley receives only 1.9 inches annually. The Sierra Nevada Mountains can receive up to 50 inches annually, much of it in the form of snow. In some years, the community of Mammoth Lakes can have snow accumulations of more than 10 feet, enough to make Mammoth Mountain one of southern California's most popular ski resorts.

Figure 9-3. South Lahontan Hydrologic Region



Although far from densely populated, the region contains some rapidly growing urban areas, including the cities of Lancaster and Palmdale in the Antelope Valley of Los Angeles County, and the Victor and Apple valleys of San Bernardino County. Many of the new residents in these valleys are workers who have chosen a long commute to the greater Los Angeles area in exchange for affordable housing. Future population growth in the region is expected to be concentrated in these cities within commuting distance of the Los Angeles area. Bishop, Ridgecrest, and Barstow are other population centers in the region. The economies of these and other small towns in the eastern part of the region are tied to the region's numerous military facilities and other governmental employers, and to providing services for travelers and tourists.

Public lands constitute about 75 percent of the region's area, providing a major recreational resource. Popular destinations in the region include the Mono Lake area, June Lakes and Mammoth Lakes, Inyo National Forest, Death Valley National Monument, and the recently created Mojave National Reserve. Only about 1 percent of the region's land is used for urban and agricultural purposes. Most of the irrigated acreage is in the Mono-Owens planning subarea, primarily for alfalfa and pasture. (This PSA includes Owens Valley, the Lake Crowley area northwest of Bishop, and Hammil and Fish Lake valleys.) Throughout the region, alfalfa and pasture are the dominant irrigated crops. Some deciduous orchard acreage is found in the western part of the region. Table 9-7 shows population and crop acreage for the region.

Table 9-7. Population and Crop Acreage (in thousands)

	1995	*2020*
Population	713	2,019
Irrigated Crop Acres	61	45

☞Photo: Owens River

The major (perennial) waterbodies in the region are in the northeast part -- Mono Lake and Owens River. Since there is relatively little perennial surface water in rest of the region, the region's environmental water use is concentrated in the Mono Lake - Owens Valley corridor. The major environmental water use requirements are associated with maintenance of Mono Lake

levels for migratory birds, and fishery instream flow requirements for the Owens River system, resulting from regulatory actions described in Chapter 2. DFG operates four fish hatcheries in the Mono-Owens area: Mt. Whitney, Big Springs, Hot Creek, and Black Rock hatcheries.

The largest surface water development in the region is the Los Angeles Aqueduct and its associated facilities, described in the following section. There are also a few relatively small, high-elevation dams operated by Southern California Edison for nonconsumptive hydropower purposes. These dams do not provide water supply for the region. One reservoir in the region is the SWP's Lake Silverwood on the East Branch of the California Aqueduct, a facility to regulate and store imported water. In the San Bernardino Mountains, Lake Arrowhead, owned by the Arrowhead Lake Association, is a 48,000 af reservoir that provides recreational opportunities and water supply for lakeshore residents. Littlerock Dam on Littlerock Creek impounds a 2,700 af reservoir that provides water supply for the Palmdale area in Antelope Valley.

Water Demands and Supplies

The water budget for the South Lahontan Region is shown in Table 9-8. Increased environmental water demands from recently settled court actions involving LADWP's water diversions from the Owens Valley and Mono Lake are included in the base water budget. A pending order issued by the air pollution control district in 1997 which could increase environmental water demands in the region by an additional 51 taf per year. This increase is not included in the water budget because LADWP is planning to appeal the order. This subject is discussed in the local water resources management issues section.

Table 9-8. South Lahontan Region Water Demands and Supplies (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Applied Water				
Urban	238	238	619	619
Agricultural	332	332	257	257
Environmental	107	81	107	81
Total Applied Water	**676**	**651**	**983**	**957**
Supplies				
Surface Water	322	259	545	441
Groundwater	239	273	227	279
Recycled and/or Desalted	27	27	27	27
Total Supplies	**587**	**559**	**799**	**747**
Shortages	**89**	**92**	**184**	**210**

Los Angeles Aqueduct.

The Los Angeles Aqueduct is the region's major water development feature, although the aqueduct does not serve water to the region. In 1913, the first Los Angeles aqueduct was completed and began conveying water from the Mono-Owens area to the city of Los Angeles. A second Los Angeles aqueduct was completed in 1970. The aqueducts were designed to divert the flows of streams tributary to Mono Lake, as well as Owens River water. The combined carrying capacity of both aqueducts amounts to 780 cfs. Both aqueducts terminate at the 10,000 af Los Angeles Reservoir in the South Coast region. The first aqueduct begins at the intake on Lee Vining Creek and the second begins at Haiwee Reservoir.

There are seven major reservoirs in the LAA system with a combined storage capacity of about 325,000 af (Table 9-9). These reservoirs were constructed to store and regulate flows in the aqueduct. The northernmost reservoir is Grant Lake Reservoir in Mono County with a capacity of 47,600 af. Crowley Lake Reservoir, also located in Mono County is the system's largest with a capacity of 184,200 af. Six of the seven reservoirs are located in the South Lahontan region. Bouquet Reservoir is in the South Coast region.

Table 9-9. Los Angeles Aqueduct System Reservoirs[1]

Reservoir Name	Capacity (af)	County
Grant Lake	47,600	Mono
Crowley Lake	184,200	Mono
Pleasant Valley	3,000	Inyo
Tinemaha	16,300	Inyo
Haiwee	39,300	Inyo
Fairmont	500	Los Angeles
Bouquet	33,800	Los Angeles

[1] All reservoirs are located in the South Lahontan Region except Bouquet

On its way to Los Angeles, water from both aqueducts passes through 11 power plants. The energy generated is over 1 billion kWh, enough to supply the needs of 220,000 homes.

State Water Project

The East Branch of the California Aqueduct follows the northern edge of the San Gabriel Mountains, bringing imported water to Silverwood Lake. Table 9-10 shows SWP contractors in the region and their contractual entitlements.

Table 9-10. SWP Contractors in the South Lahontan Region

Contractor	Entitlement (af)	1995 Deliveries (af)
Antelope Valley-East Kern Water Agency	138,400	47,300
Crestline-Lake Arrowhead	5,800	411
Littlerock Creek Irrigation District	2,300	480
Mojave Water Agency	50,800[1]	8,722
Palmdale Water District	17,300	6,961

[1] Effective January 1, 1998, MWA assumes 25,000 af of KCWA's entitlement which will increase MWA's entitlement to 75,800.

Antelope Valley-East Kern Water Agency, the largest SWP contractor in the region, serves 5 major and 16 small municipal agencies, as well as Edwards AFB, Palmdale Air Force Plant 42, and US Borax and Chemical Facilities. AVEK was formed to bring imported water into the area.

MWA was created in 1960 in response to declining groundwater levels in the area. All communities within MWA's boundaries have no source of supply other than groundwater.

Communities served by MWA include Barstow, Apple Valley, Hesperia, and Victorville. (Most of MWA's service area is within the South Lahontan region. Part of the service area extends into the Lucerne and Johnson valleys, and the Morongo Basin in the Colorado River hydrologic region; 7,257 af of MWA's SWP entitlement is allocated to that area.)

MWA has taken little of its SWP entitlement to date, due to lack of conveyance facilities. In 1994, MWA completed its Morongo Basin pipeline, a 70-mile pipeline with a capacity of 100 cfs from the East Branch to the Mojave River (7 miles) and then 20 cfs to the Morongo Basin and Johnson Valley. This pipeline allows MWA to bring Project water into part of its large (almost 5,000 square miles) service area. In 1997, MWA began construction of its 70-mile long Mojave River Pipeline (94 cfs capacity) to bring imported water to Barstow and neighboring cities. The El Mirage aqueduct is the next proposed addition to its distribution system. The aqueduct would deliver approximately 4,000 af of imported water from the SWP East Branch near the Los Angeles/San Bernardino county line to the westernmost subarea of the Mojave River basin near El Mirage. The imported water would be used to recharge the area's overdrafted groundwater basin.

In 1997, the MWA and Berrenda-Mesa Water District (a member agency of KCWA) concluded the permanent transfer of 25,000 af of SWP entitlement, thereby increasing MWA's total entitlement to 75,800 af.

Local Surface Water Supplies

The Mammoth Community Water District supplies the town of Mammoth Lakes, located at the northern end of the region. About 70 percent of MCWD's supply comes from Lake Mary, the largest of a number of small alpine lakes in the Mono Lakes basin. At present, the remainder of MCWD's supply comes from groundwater. Although MCWD serves a permanent population of only about 5,000 people, its average daily population is about 13,000, with peak weekends and holiday periods reaching 30,000 people per day. These wide fluctuations in service levels above the base population are typical of the recreational and resort communities in the area.

Although the Mojave River appears on maps as a major waterway in the region, it is an ephemeral stream for much of its length. Local communities extract groundwater, which is recharged by river flows, but do not directly divert significant amounts of surface water from the

river. There is one dam on the Mojave River at the edge of the San Bernardino Mountains -- Mojave River Forks Dam, a USACE flood control facility.

The 2,700 af capacity Littlerock Reservoir provides water supply to Littlerock Creek Irrigation District and to Palmdale Water District. During a recent seismic rehabilitation of the 1924-vintage dam, PWD funded part of the work in exchange for access to the water supply. Water from Littlerock Reservoir may be released into a ditch that conveys flows to PWD's Lake Palmdale, a 3,900 af storage reservoir.

☞Photo: renovated Littlerock Creek dam

Lake Arrowhead in the San Bernardino Mountains is used primarily for recreational purposes, but also provides water supply to homeowners' association members.

Groundwater Supplies

Historically, the South Lahontan Region has relied mostly on groundwater, which is the only water supply available in some parts of the region. Groundwater basin capacities in both the Mojave River and Antelope Valley Planning Study Areas, for example, total about 70 maf each. (Economically usable storage is significantly less than this amount.) Water quality influences the groundwater availability. Some areas in the Mono-Owens area have highly mineralized groundwater due to geothermal activity, while saline groundwater is not uncommon in areas near playa lakes. Several of the region's groundwater basins are in overdraft.

Searles Lake

The Mojave Desert has numerous playa lakes, dry or semi-dry lakebeds that occupy topographic low points in closed drainage basins. Playa lakes contain surface water only briefly after the region's infrequent rains. There may, however, be high groundwater levels immediately beneath an apparently dry lakebed. Groundwater found near these lakebeds is usually too mineralized for most beneficial uses, because salts have been concentrated (over thousands of years) in lakebed deposits during evaporation of the surface waters. Searles Lake in northwestern San Bernardino County is an example of an extremely mineralized playa lake.

Within geologic time, California's climate was much wetter than it is today. During the late Quaternary Period, the Owens River flowed into several (now dry) lakes in the Mojave Desert, filling Searles Lake to a depth of over 600 feet. Long-term deposition of evaporates in the lakebed created thick layers of salts and borate minerals. These deposits have been the basis of extensive mining operations at the lake, estimated to have produced more that $1 billion dollars worth of mineral commodities.

Borax mining at the lakebed began as early as 1874. Current mining techniques entail pumping brines from lakebed sediments and processing them at onsite chemical plants to produce commodities such as sodium carbonate, sodium borate, and sodium sulfate. These chemicals are used in the manufacture of drugs, dyes, glass, glaze, paper, soap, detergent, enamel, chemical products, abrasives, gasoline additives, fire retardants, and metal alloys.

The Mojave River groundwater basin is a large alluvial formation in the Mojave Desert, the only local water source for residents in the western third of San Bernardino County (part of the basin is in the Colorado River Region). The Mojave River and groundwater basin act as one water source, with the river providing the only major recharge to the basin and groundwater discharging in several places to provide surface flows in the Mojave River. The basin is divided into subareas at hydrogeologic boundaries including the Helendale and Waterman faults. The operational storage capacity of the basin is about 4.9 maf, but currently there is about 3.0 maf of water in storage. Due to overextractions the basin has experienced declining groundwater levels (see Mojave River Basin Adjudication section).

The Antelope Valley groundwater basin underlies the closed drainage in the westernmost part of the Mojave Desert in northern Los Angeles and southeastern Kern counties. It provides most of the local water supplies to users in the high desert from the San Gabriel Mountains to the Sierras, including Edwards Air Force Base. Agricultural pumping from the basin has declined

for several decades while urban extraction has increased as a result of the rapid increase in population.

Local Water Resources Management Issues

Owens Valley Area

At the turn of the century, the City of Los Angeles faced a severe shortage of water due to a growing urban population. In 1913, the City of Los Angeles completed its first aqueduct from Owens Valley to the City of Los Angeles. This aqueduct has a carrying capacity of 480 cfs. Due to increased population and industries in Los Angeles, a second aqueduct was completed in 1970 with a capacity of 300 cfs. LADWP diverts both surface water and groundwater from the Owens Valley and surface water from the Mono Basin.

In 1972, the County of Inyo filed a suit against the City of Los Angeles claiming that increased groundwater pumping for the second aqueduct was harming the Owens Valley environment. Inyo County asked that LADWP's groundwater pumping be analyzed in an Environmental Impact Report. LADWP prepared an EIR in 1976 and another in 1979, both of which the Third District Court of Appeal found inadequate. In 1983, Inyo County and LADWP decided to work together to develop an EIR and water management plan that would settle the litigation.

A third EIR was prepared jointly by LADWP and Inyo County and released in 1990. In 1991, both parties executed a long-term water management agreement delineating how groundwater pumping and surface water diversions would be managed to avoid significant decreases in vegetation, water-dependent recreational uses and wildlife habitat. However, several agencies, organizations, and individuals challenged the adequacy of the EIR and in 1993 were granted *amici curiae* status by the Court of Appeals, allowing them to enter in the EIR review process. An MOU was agreed to in 1997, ending more than 25 years of litigation between Los Angeles and Inyo County.

Los Angeles and Inyo County have now begun discussions on how to implement provisions of the 1991 agreement, 1990 EIR, and 1997 MOU. Timelines for many provisions have already been developed and plans for such major activities as re-watering the Lower Owens river are under review.

Surface water diversions from the Owens Valley have dried up Owens Lake since the 1930s. On windy days, the dust from the dried lake bed creates health and safety concerns in neighboring communities. In July 1997, the Great Basin Unified Air Pollution Control District issued an order to control Owens Lake dust. Under the order, 8,400 acres of the lake bed would be permanently flooded with a few inches of water, another 8,700 acres would be planted with grass and irrigated, while 5,300 acres would be covered with a four-inch layer of gravel. This order could cost the City of Los Angeles 51 taf of water a year or about 15 percent of LADWP's supply. The city is planning to appeal the order.

Mono Basin

Mono Lake, located just east of Yosemite National Park at the base of the eastern Sierra Nevada, is the second largest lake completely within California. It has long been recognized as a valuable environmental resource because of its scenic and biological characteristics. The area is famous for its tufa towers and spires, structures formed by years of mineral deposition by the lake's saline waters. The lake has no outlet and there are two islands in the lake that provide a protected breeding area for large colonies of California gulls and a haven for migrating waterfowl.

Much of the water flowing into Mono Lake comes from snowmelt runoff in fresh water creeks. Since 1941, LADWP has diverted water from Lee Vining, Walker, Parker, and Rush creeks into tunnels and pipelines that carry the water to the Owens Valley drainage; it is eventually transferred, together with Owens River flows, to Los Angeles via the Los Angeles Aqueduct.

Diversions of instream flow from its tributaries lowered Mono Lake's water level to an historic low of 6,372 feet above sea level in 1981. With decreased inflow of fresh water, the lake's salinity increased dramatically. In addition, when water levels drop to 6,375 feet or lower, a land bridge to Negit Island is created, allowing predators to reach gull rookeries; this first happened in 1978 and again during the 1987-92 drought.

As a result of these impacts, the lake and its tributaries have been the subject of extensive litigation between the Los Angeles and environmental groups since the late 1970s. In 1983, the California Supreme Court ruled that SWRCB has authority to reexamine past water allocation decisions and the responsibility to protect public trust resources where feasible. Following a long

series of court decisions which mandated protection for the lake, the SWRCB issued a final decision on Mono Lake (Decision 1631) in 1994. The amendments to LA's water right licenses are set forth in the order accompanying the decision.

The order sets instream flow requirements for the protection of fish in each of the four streams from which LADWP diverts water. The order also establishes water diversion criteria to protect wildlife and other environmental resources in the Mono Basin. These water diversion criteria: (1) prohibit the export of water from the Mono Basin until the water level of Mono Lake reaches 6,377 feet above mean sea level; and (2) restrict Mono Basin water exports to allow the water level of Mono Lake to rise to an elevation of 6,391 feet in about 20 years. Once the water level of 6,391 feet is reached, it is expected that LADWP will be able to export about 30.8 taf of water per year from the Mono Basin. The order also requires LADWP to prepare restoration plans to restore the four streams from which it diverts water and to restore a portion of the waterfowl habitat which was lost due to the decline of Mono Lake. In May 1997, parties to the restoration planning process presented a signed settlement on Mono Basin restoration to the SWRCB. If approved, the settlement would guide restoration activities and annual monitoring through 2014. The parties to the settlement include LADWP, the Mono Lake Committee, DFG, State Lands Commission, DPR, California Trout, National Audubon Society, USFS, BLM, and The Trust for Public Land.

The main thrust of the restoration plan is to restore the natural processes that created the Mono Basin's stream and waterfowl habitats. Key features of stream restoration plan include:

- restoration of peak flows to Rush, Lee Vining, Walker, and Parker creeks;
- reopening certain abandoned channels in Rush Creek; and
- a monitoring plan with specific criteria for restoration

One of the restoration actions required by the SWRCB — bypassing sediment around LADWP diversion dams — was deferred for further analysis.

The waterfowl habitat restoration plan proposes a Mono Basin Waterfowl Habitat Restoration Foundation to administer a $3.6 million trust fund established by LADWP. Five of the parties to the agreement would serve as initial members of the foundation. Activities would include annual monitoring, restoring open water habitat adjacent to the lake, and rewatering Mill Creek. LADWP would continue its brine shrimp productivity studies, open several channels on

Rush Creek, and make its Mill Creek water rights available for rewatering Mill Creek, based on the recommendations of the foundation.

The plans are being held under consideration by the SWRCB and a decision is expected at the end of 1997.

Mojave River Adjudication

The Mojave River groundwater basin has experienced overdraft conditions since the early 1950s. The largest increase in overdraft occurred in the 1980s. About 80 percent of the total basin recharge comes from the Mojave River. In 1990, the City of Barstow filed a complaint with the San Bernardino Superior Court requesting an average annual guaranteed flow of 30 taf to mitigate reduced runoff and declining groundwater levels in the Barstow area. The complaint also requested a writ of mandate against the MWA to compel it to import water from the State Water Project. MWA filed a cross-complaint requesting a determination of water rights in the basin.

In October 1991, the court ordered that the litigation be placed on hold to give the parties time to negotiate a settlement and to develop a solution to the overdraft. A Mojave Basin adjudication committee was formed. To facilitate data gathering and drafting a stipulated judgment and physical solution. The court's final ruling on basin adjudication was issued in January 1996. In its ruling, the court emphasized that the area has been in overdraft for decades and that MWA must alleviate overdraft through conservation and purchase of supplemental water. MWA was appointed as the basin Watermaster.

The adjudication stipulated that any party pumping more than 10 acre-feet per year becomes a party to the judgment and is bound by it. The judgment states that each party has a right to its base annual production, which was its highest usage between 1986 and 1990. However, the judgment also requires MWA to reduce this amount by at least 5 percent each year for four years as one way to achieve a physical solution to the longstanding overdraft. Any party exceeding its annual allotment must purchase replenishment water from MWA or from other parties to the judgment. If there is still overdraft after the end of the first five years of the stipulated judgment, then water use in the basin subareas in overdraft will be further reduced. The judgment recognizes five basin subareas and requires that if an upstream subarea does not

meet its obligation to a downstream subarea, the upstream area must provide the costs of supplemental water.

Supplemental water to the Mojave River basin will come from MWA's SWP entitlement, or from purchases from willing sellers, and will be delivered through the California Aqueduct. In March 1997, MWA began constructing its Mojave River pipeline, extending about 70 miles from the California Aqueduct to Newberry Springs, a rural community east of Barstow. MWA also recently purchased the permanent right to 25 taf of additional SWP annual entitlement, nearly a 50 percent increase from the agency's previous entitlement. The combination of reduced pumping, increased SWP deliveries and other imports, and new delivery facilities are expected to reduce overdraft in the Mojave River basin.

Antelope Valley Water Management

The Antelope Valley Water Group was formed in 1991 to provide coordination among valley agencies water interests. AVWG members include the Cities of Palmdale and Lancaster, Edwards AFB, AVEK, Antelope Valley United Water Purveyors Assocation, Los Angeles County Waterworks Districts, PWD, Rosamond Community Services District, and Los Angeles County. In an attempt to prepare a water resources study with a regional focus, AVWG initiated an Antelope Valley Water Resources Study, which was completed in 1995.

The Antelope Valley Water Resources Study evaluated the valley's existing and future water supplies from groundwater, the SWP, Little Rock Reservoir, and recycling, and compared these supplies with projected water demands. The study concluded that water supply reliability is low in the study area -- full 1998 demands will be met only half the time without overdrafting groundwater resources. The study recommended several water conservation, recycling, and conjunctive use measures to reduce expected shortages.

The study identified three sites (two on Amargosa Creek and one on Little Rock Creek) with high potential for groundwater recharge through spreading and identified SWP water, recycled water, and natural runoff as potential source for recharge through spreading. The study also identified several potential groundwater injection sites within existing Los Angeles County Waterworks and PWD municipal wellfields. Treated SWP water was identified as a potential source for recharge through injection.

In January 1996, PWD adopted a water facilities master plan and developed a draft EIR for its service area. The plan updated a previous 1988 plan for which an EIR was completed in 1989. PWD currently relies on three water sources: Littlerock Creek Reservoir, local groundwater and SWP water. The plan indicates that about 40 percent of PWD'S supply is from groundwater. Declining groundwater levels have been a local concern in the Palmdale area, although extractions presently appear to be within the basin's perennial yield. The plan also indicates that existing supplies are insufficient to meet dry year demands. Average year shortages are projected to occur by 2005.

To meet dry year demands, the plan calls for the construction of up to 12 new production wells. The draft EIR identified declining groundwater levels as an unavoidable significant impact of the plan to construct new production wells. Several mitigation measures are recommends, including: conservation and restrictions during drought years; conjunctive use programs (as identified in the Antelope Valley Water Resources Study) in cooperation with other water users in the Antelope Valley; acquiring an additional 3.1 taf per year of SWP entitlements; participate in water transfers; and develop reclaimed water.

Interstate Groundwater Basins

California and Nevada share the use of three interstate groundwater basins in the South Lahontan region: Fish Lake Valley, crossed by Highway 168 east of Westgard Pass; Pahrump Valley, located to the east of Death Valley; and Mesquite Valley, just south of Pahrump Valley. On the California side of the border, groundwater extraction supports small-scale agricultural development, largely for alfalfa. Pahrump Valley is the most populated of the three valleys, with the majority of the development located on the Nevada side of the stateline, in and around the community of Pahrump. Pahrump and Mesquite valleys are within about 35 miles of the rapidly growing Las Vegas metropolitan area. In the early 1990s, the Southern Nevada Water Authority proposed exporting groundwater from several rural counties in central Nevada to help meet Las Vegas's rapidly increasing need for water. However, opposition by rural Nevada counties to SNWA's proposal caused SNWA to defer this project. Inyo County residents have historically been concerned about the proximity of Los Vegas to the interstate basins, although no new interstate issues have come up since SNWA's proposed project.

Water Management Options for South Lahontan Region

Agencies throughout the region are in various stages of developing plans to improve water service reliability of their service areas. Table 9-11 shows the comprehensive options list for the South Lahontan Region. Only two local options were retained for the evaluation (see Table 9A-2 in Appendix 9A).

Water Conservation

Urban. No significant depletion reductions due to urban conservation are expected in this region. Most wastewater treatment plant effluent is used to recharge the region's depleted groundwater basins, and outdoor landscape water use in the region is already at about 0.8ETo.

Agricultural. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Increased investment in low-volume irrigation technology and changes in water management practices such as increased use of irrigation scheduling or irrigation management to attain seasonal application efficiencies of 76 percent to 80 percent were evaluated as agricultural conservation options. It is estimated that water savings of less than 1 taf could be achieved in this region, since most users are already irrigating at high efficiencies. Options for flexible water delivery and canal lining and piping are not feasible in this region because most water supply comes from individual wells with minimal conveyance facilities.

Modify Existing Reservoirs/Operations

Sediment has accumulated behind the dam of Littlerock Reservoir and minor additional yield could be realized by removing the sediment. Studies are now underway to evaluate the costs and benefits of this option. Preliminary estimates indicate that the cost of this option is in the order of $2,000 per af. Because of the high costs, this option was deferred.

New Reservoirs

There are no proposed new reservoir developments in this region. The region's aridity and consequent lack of surface water resources make new reservoirs infeasible. Future local water resources development will be based on groundwater sources.

Table 9-11. South Lahontan Region Comprehensive List of Options

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to 0.8ETo	Defer	No substantial depletion reductions attainable.
	Residential Indoor Water Use	Defer	No substantial depletion reductions attainable.
	Interior CII Water Use	Defer	No substantial depletion reductions attainable.
	Distribution System Losses	Defer	No substantial depletion reductions attainable.
Agricultural			
	Seasonal Application Efficiency Improvements	Defer	No substantial depletion reductions attainable.
	Flexible Water Delivery	Defer	No substantial depletion reductions attainable.
	Canal Lining and Piping	Defer	No substantial depletion reductions attainable.
	Tailwater Recovery	Defer	No substantial depletion reductions attainable.
Modify Existing Reservoirs/Operations			
	Remove sediment from Littlerock Reservoir	Defer	Excessive high costs for additional yield.
New Reservoirs/Conveyance Facilities			
	---	---	---
Groundwater/Conjunctive Use			
	---	---	---
Water Transfers/Banking/Exchange			
	Mojave Water Agency	Retain	
	Palmdale Water District	Retain	
Water Recycling			
	Water recycling options	Defer	Water recycling options identified in the 1995 survey for this region does not generate new water supply.
Desalination			
Brackish Groundwater			
	---	---	---
Seawater			
	---	---	---
Other Local Options			
	Line Palmdale Ditch	Defer	No net increase in supply.
	Reduce Outflow to Playa Lakes	Defer	Restrictions on use of flows that provide recharge to overdraft basins. Costs are high and water quality is poor.
Statewide Options			
	CALFED Bay / Delta Program	Retain	
	SWP Interim South Delta Program	Retain	
	SWP American Basin Conjunctive Use Program	Retain	
	SWP Supplemental Water Purchase Program	Retain	
	Enlarge Shasta Lake	Retain	

Water Transfers and Banking

The California Aqueduct could convey purchased water to MWA's distribution system for region's rapidly urbanizing areas. As previously noted, MWA just completed the permanent purchase and transfer of 25,000 af of SWP entitlement water from Berrenda-Mesa Water District in the San Joaquin Valley. MWA is also pursuing two demonstration water transfer projects of 2,000 af each. PWD is also seeking to transfer 3,100 af of SWP contractual entitlement from Central Valley agricultural water purveyors. Other voluntary water transfers could be developed through option agreements, storage programs, and purchases of water through the drought water bank or other similar spot markets.

Capacity has been developed to store additional imported supplies in the Mojave River basin at MWA's Rock Springs groundwater recharge facility near Hesperia. Additional recharge facilities in the Barstow area are in the final planning stages, which would further increase MWA's ability to take delivery of imported supplies when its Mojave River Aqueduct is completed. Sufficient basin storage is available to store water in wet years when more SWP supplies or purchased supplies might be available.

Water Recycling

Water recycling options are deferred for this region because planned projects reported in the 1995 DWR and WateReuse survey would not generate new supply.

Other Local Options

Line Palmdale Ditch. The ditch that conveys water from Litterock Reservoir to Palmdale Lake has an estimated 20 percent conveyance loss, which could be reduced by canal lining. Canal lining would reduce groundwater recharge by an estimated 7,000 af, resulting in no net increase in water supply. This option was deferred.

Reduce Outflow to Playa Lakes. Some of the flow of the Mojave River reaches Soda Lake, a playa, where the flow is lost to evaporation. Outflow past Afton Canyon averages 8,400 af per year; however, the basin adjudication restricts use of flows, that provide recharge to downstream subareas of the basin that are in overdraft. This option was deferred.

Likewise, local storm runoff collects in many small playas throughout the basin. These playas generally do not contribute to groundwater recharge, due to the low permeability of playa soils. Water collected in the playas evaporates, rather than recharging groundwater. Diversion

or collection of runoff to playas and recharging it to groundwater basins could result in increased groundwater supplies by elimination of the evaporation. Six dry lakebeds could potentially store an additional 1,800 af perhaps once every five years. Costs for this option are $1,000 to $3,300 per af. Water quality at the playas is generally poor, with high levels of salts and minerals. This option was deferred.

Statewide Options

Active planning for statewide water supply options is being done currently for the CALFED Bay-Delta Program and for SWP future supply. See Chapter 6 for discussion on statewide water supply augmentation options. *[The following text on statewide supplies has placeholders for potential outcomes of CALFED process. Text will be changed as CALFED results become available. No decisions have yet been made as to CALFED Bay-Delta program facilities or allocation or their yield.]*

CALFED Bay-Delta Program. Improving conditions in the Sacramento-San Joaquin River Delta would increase SWP supply reliability. For illustrative purposes, assuming improved Delta conditions through the implementation of CALFED alternatives, additional SWP yield to the region could be 8,000 and 9,000 af in average and drought years, respectively.

State Water Project Improvements. As additional conveyance facilities to deliver SWP water to the region are constructed, reliability of SWP supplies will become more critical. The Department has three programs underway which would improve SWP yields to its contractors in the South Lahontan region. These programs are discussed in Chapter 6. The ISDP would augment SWP supplies to the region by 10 taf and 7 taf in average and drought years, respectively. The American Basin Conjunctive Use Program would provide 7 taf to the region in drought years, and the Supplemental Water Purchase Program could provide an additional 11 taf in drought years.

Enlarged Shasta Lake. Enlarging Shasta to 13 maf of storage would increase drought year yield by about 1.5 maf. If we assume one-third of this yield is allocated to the environment, and the remaining two-third is allocated among the State and federal projects, the South Lahontan Region could potentially receive 34 taf and 38 taf in average and drought years respectively.

Water Resources Management Plan for the South Lahontan Region

By 2020, water shortages for the region are estimated to be 184 taf and 210 taf in average and drought years respectively. Most of the region's shortage will be in the Mojave River planning subarea which will have average and drought year shortages. Water shortages in the Antelope Valley subarea are forecast only in drought years.

Table 9-12 shows the ranking of options. The most likely options to be implemented to meet future shortages in this region (Table 9-13) will involve SWP supplies and water transfers conveyed by the California Aqueduct.

Improving SWP supply reliability through a Delta fix would also provide the region with additional supply.

Table 9-12. South Lahontan Region Options Evaluation

Option	*Rank*	*Cost per af ($)*	*Potential Gain (taf)*	
			Avg	*Drt*
Water Transfers/Banking/Exchange				
Mojave Water Agency	H		4	4
Palmdale Water District	H		3	3
Statewide Options				
CALFED Bay / Delta Program	M		8	9
SWP Interim South Delta Program	M		10	7
SWP American Basin Conjunctive Use Program	H	150	--	7
SWP Supplemental Water Purchase Program	L	175	--	11
Enlarge Shasta Lake	M		34	38

Table 9-13. Summary of Options Most Likely to be Implemented by 2020 South Lahontan Region

Option	Potential Gain (taf)	
	Avg	Drt
Shortage	184	210
Conservation	-	-
Modify Existing Reservoirs/Operations	-	-
New Reservoirs/Conveyance Facilities	-	-
Groundwater/Conjunctive Use	-	-
Water Transfers/Banking/Exchange	7	7
Recycling	-	-
Desalination	-	-
Statewide Options	18	23
Total Potential Gain	25	30
Remaining Shortage	159	180

Colorado River Hydrologic Region

Description of the Area

The Colorado River Region encompasses the southeastern corner of California. The region's northern boundary, a drainage divide, begins along the southern edge of the Mojave River watershed in the Victor Valley area of San Bernardino County and extends northeast across the Mojave Desert to the Nevada state line. The southern boundary is the Mexican border. A drainage divide forms the jagged western boundary through the San Bernardino, San Jacinto, and Santa Rosa mountains, and the Peninsular Ranges (which include the Laguna Mountains). The Nevada state line and the Colorado River (the boundary with Arizona) delineate the region's eastern boundary. (See Figure 9-4)

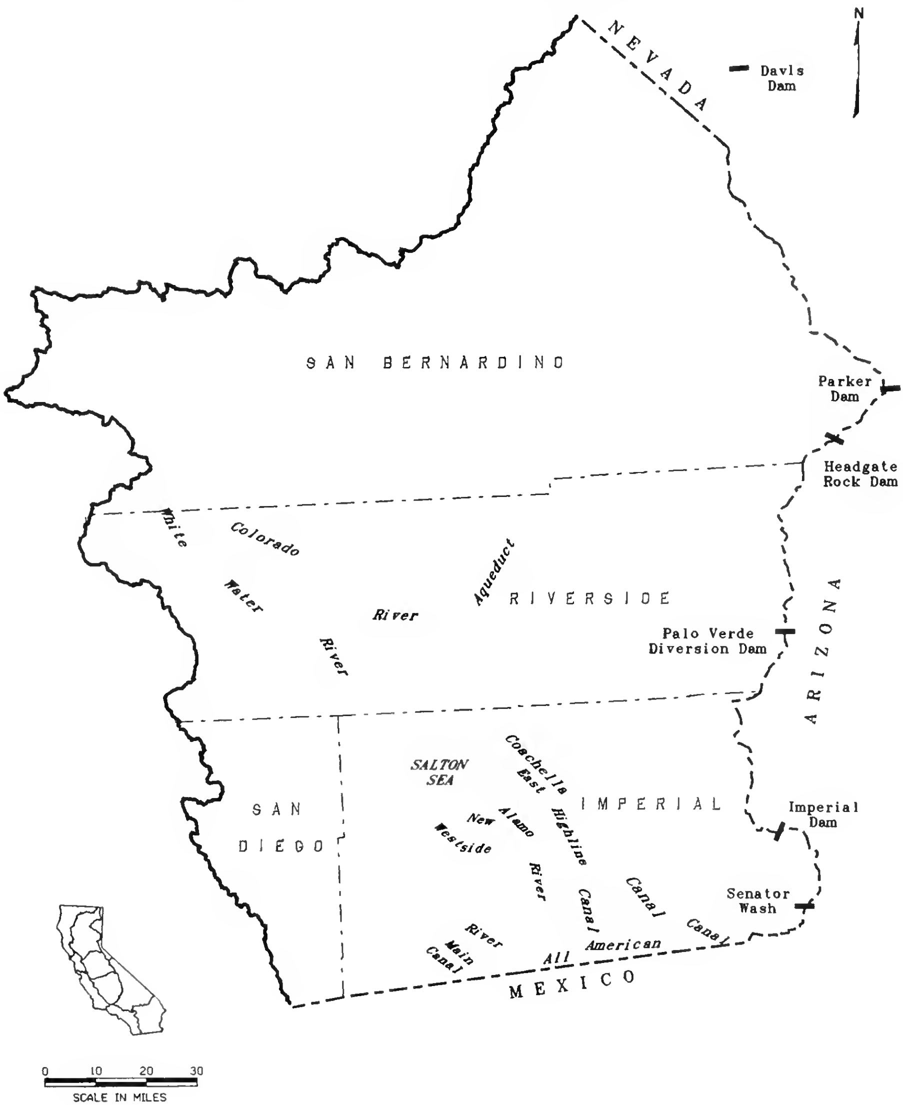
Covering over 12 percent of the total land area in the State, the region is California's most arid. It includes volcanic mountain ranges and hills; distinctive sand dunes; broad areas of Joshua tree, alkali scrub, and cholla communities; and elevated river terraces. Much of the region's topography consists of flat plains punctuated by numerous hills and mountain ranges. The San Andreas fault traverses portions of the Coachella and Imperial valleys. A prominent topographic feature is the Salton Trough in the south-central part of the region.

The climate for most of the region is subtropical desert. Average annual precipitation is much higher in the western mountains than in the desert areas. Winter snows generally fall above 5,000 feet; snow depths can reach several feet at the highest levels during winter. Most of the precipitation in the region falls during the winter; however, summer thunderstorms can produce rain and local flooding in many areas. Despite its dry climate and rugged terrain, the region contains productive agricultural areas and popular vacation resorts. Table 9-14 shows the region's population and crop acreage for 1995 and 2020.

Table 9-14. Population and Crop Acreage (in thousands)

	1995	*2020*
Population	533	1,096
Irrigated Crop Acres	749	750

Figure 9-4. Colorado River Hydrologic Region



Most of the population is concentrated in the Coachella and Imperial valleys. Major cities in the Coachella Valley include Palm Springs, Indio, and Palm Desert. Other urban centers in the region are the Cities of El Centro, Brawley, and Calexico in Imperial Valley; the cities of Beaumont and Banning in the San Gorgonio Pass area; and the cities of Needles and Blythe along the Colorado River. Urban development in the Coachella Valley is proceeding rapidly.

☞Photo: date palms in Coachella Valley

Agriculture is an important source of income for the region. Almost 90 percent of the developed private land is used for agriculture, most of which is in the Imperial, Coachella, and Palo Verde valleys. The primary crops are alfalfa, winter vegetables, spring melons, table grapes, dates, Sudan grass, and wheat. Recreation and tourism are another important source of income for the region. In Coachella Valley, the Palm Springs area and adjoining cove communities are an important resort and winter golf destination. Recreational opportunities provided by the more than 90 golf courses in the Coachella Valley, water-based recreation on the Colorado River and Salton Sea, and desert camping all contribute to the area's economy.

Water Demands and Supplies

Table 9-15 shows the water budget for the Colorado River Region. Agricultural water demand makes up the majority of the water use in the region. There are two major areas where water is used for wildlife habitat in the region, the Salton Sea National Wildlife Refuge and the Imperial Wildlife Area. There are also several private wetlands.

About 90 percent of the region's water supply is from surface deliveries from the Colorado River (through the All-American and Coachella Canals, local diversions, and the Colorado River Aqueduct by means of an exchange for SWP water). Other supplies are from groundwater, SWP water, local surface water, and recycled water. Groundwater overdraft in 1995 was estimated to be about 70 taf.

Major water agencies in the region are the Palo Verde Irrigation District, Imperial Irrigation District, Coachella Valley Water District, Bard Water District, Mojave Water Agency, Desert Water Agency, and San Gorgonio Pass Water Agency.

Water shortages are expected under both average and drought conditions in the Colorado River Region. The primary shortages with existing supplies are expected to occur in the

Coachella planning subarea because of groundwater overdraft. (In the future, reduction in California's Colorado River water use from 5.3 maf to 4.4 maf will create an average year shortage in the South Coast Region. This year 2020 shortage is shown in the South Coast water budget.)

Table 9-15. Colorado River Region Water Demands and Supplies (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Applied Water				
Urban	418	418	740	740
Agricultural	4,118	4,118	3,583	3,583
Environmental	39	38	44	43
Total Applied Water	**4,575**	**4,574**	**4,367**	**4,366**
Supplies				
Surface Water	4,154	4,128	4,023	4,013
Groundwater	337	337	251	250
Recycled and/or Desalted	15	15	15	15
Total Supplies	**4,506**	**4,479**	**4,288**	**4,278**
Shortages	**69**	**95**	**79**	**88**

Supplies from the Colorado River

Most of the water supply in the region comes from the Colorado River, an interstate (and international) river whose runoff is apportioned among the seven Colorado River Basin states by a complex body of statutes, decrees, and court decisions known collectively as the law of the river. Table 9-16 summarizes key elements of the law of the river. USBR acts as the watermaster for the Colorado River, and all users of Colorado River water must contract with USBR for their supplies. Figure 9-4 shows the location of key Colorado River storage and conveyance facilities.

Within California, local agencies' allocation of Colorado River water was established under the Seven Party Agreement (Table 9-17). Furthermore, all uses occurring within a state are charged to that state's allocation under the law of the river. Thus, federal water uses or uses associated with federal reserved rights (e.g., tribal water rights) must also be accommodated

within California's basic apportionment of 4.4 maf per year plus one-half of any available surface water.

Table 9-16. Key Elements of the Law of the River

Document	Date	Main Purpose
Colorado River Compact	1922	Equitable apportionment of the river among the two basins. The Upper Basin (Wyoming, Colorado, New Mexico, Utah) and the Lower Basin (California, Nevada, Arizona) are each provided a basic apportionment of 7.5 maf annually of consumptive use. The Lower Basin is given the right to increase its consumptive use an additional 1 maf annually.
Boulder Canyon Project Act	1928	Authorizes USBR to construct Boulder (Hoover) Dam and the All American Canal (including the Coachella branch), and gives congressional consent to the Colorado River Compact. Also provides that all users of Colorado River water must enter into a contract with DOI for the water.
California Limitation Act	1929	Limits California's share of the 7.5 maf annually apportioned to the Lower Basin to 4.4 maf annually, plus no more than half of any surplus waters.
Seven Party Agreement	1931	An agreement among PVID, IID, CVWD, MWDSC, city of LA, City of SD, and County of SD to divide California's apportionment among the California water users. Details are shown in Table 9-17.
U.S. - Mexican Treaty	1944	Guarantees Mexico a supply of 1.5 maf annually of Colorado River water.
Arizona v. California	1964	Apportions the Lower Basin's 7.5 maf annually among California (4.4 maf annually), Arizona (2.8 maf annually), and Nevada (0.3 maf annually). Also quantifies tribal water rights for specified tribes, including 131,400 af for diversion in California.
Colorado River Basin Project Act	1968	Requires Secretary of the Interior to prepare long-range operating criteria for major Colorado River reservoirs.
Arizona v. California	1979	Quantifies present perfected rights in the Lower Basin states.

Table 9-17. Apportionment of the Colorado River (all amounts represent consumptive use)

Interstate/International		
Upper Basin States (Wyoming, Utah, Colorado, New Mexico, small portion of Arizona)		7.5 maf
Lower Basin States (Arizona, Nevada, California)		7.5 maf
	Arizona	2.8 maf
	Nevada	0.3 maf
	California	4.4 maf
Additional Lower Basin apportionment, if water available		
	Arizona	46%
	Nevada	4%
	California	50%
Republic of Mexico[1]		1.5 maf

[1] Plus 200 taf of surplus water, when available. Water delivered to Mexico must meet salinity requirements specified in Minute 242 of the Mexican Water Treaty of 1944.

Intrastate (*Seven Party Agreement*)[2]	
Priority 1	Palo Verde Irrigation District (based on area of 104,500 ac)
Priority 2	Lands in California served by USBR's Yuma Project (not to exceed 25,000 ac)
Priority 3	Imperial Irrigation District and lands served from the All American Canal in Imperial and Coachella Valleys; and, Palo Verde Irrigation District for use on 16,000 ac in the Lower Palo Verde Mesa.
Priorities 1 through 3, collectively, are allocated 3.85 maf. There is no specified division of that amount among the three priorities.	
Priority 4	MWDSC for coastal plain of Southern California - 550,000 af
Priority 5	An additional 550,000 af to MWDSC, and 112,000 af for the City and County of San Diego[3]
Priority 6	Imperial Irrigation District and lands served from the All American Canal in Imperial and Coachella Valleys, and Palo Verde Irrigation District for 16,000 ac in the Lower Palo Verde Mesa, for a total of 300,000 af
Priority 7	All remaining water available for use in California, for agricultural use in California's Colorado River Basin.
Total of Priorities 1 through 6 is 5.362 maf	

[2] Indian tribes and miscellaneous present perfected right holders that are not identified in California's Seven Party Agreement have the right to divert up to approximately 85 taf per year (equating to about 50 taf of consumptive use) within California's 4.4 maf basic apportionment. These users are presently consumptively using approximately 32 taf per year (assuming about 25 taf of unmeasured return flow).

[3] Subsequent to execution of the Seven Party Agreement, San Diego executed a separate agreement transferring its apportionment to MWDSC.

The major local agencies in California using Colorado River water in the Colorado River Region are PVID, BWD, IID, and CVWD. The remainder of California's Colorado River water use occurs in the South Coast Region (Chapter 7). Figure 9-5 is a plot of California and Lower Basin allocations compared with historic Colorado River water use. As shown in the figure, California's use has historically exceeded its basic allocation, because California has been able to divert Arizona's and Nevada's unused apportionments, and to divert surplus water. With completion of the Central Arizona Project and the 1996 enactment of a state groundwater banking act, Arizona projects that it will use virtually all of its apportionment for the first time in 1998. The fact that California will have to reduce its Colorado River use from current levels to 4.4 maf annually has significant water management implications for the South Coast region. In calendar year 1996, the actual consumptive use of the Lower Basin states was:

Nevada	248 taf
Arizona	2,553 taf
California	5,226 taf
Total Lower Basin	8,027 taf

Within the Colorado River Region, IID, BWD, and PVID receive virtually all of their supplies from the Colorado River. IID and CVWD's Colorado River supplies are diverted into USBR's All American Canal at Imperial Dam; CVWD is served from the Coachella Branch of the AAC. PVID diverts directly from the Colorado River near Blythe. BWD receives its supplies from facilities of USBR's Yuma Project, which serves lands in both California and Arizona.

☞Photo: Imperial Dam

The interstate allocations provided in the 1922 Compact were made at a time of relatively wet hydrology on the Colorado River. Some have suggested that the allocations overstate the river's normally available water supply, even without consideration of subsequent calls on that water supply for tribal water rights and endangered species fishery water needs. Table 9-18 provides an overview of average river hydrology. Although consumptive use in the Lower Basin is at 7.5 maf, Upper Basin use is well below that amount. Current projections are that the Upper Basin will not reach a consumptive use of 7.5 maf until after 2060.

Figure 9-5. Lower Basin Allocations and Consumptive Use (taf)

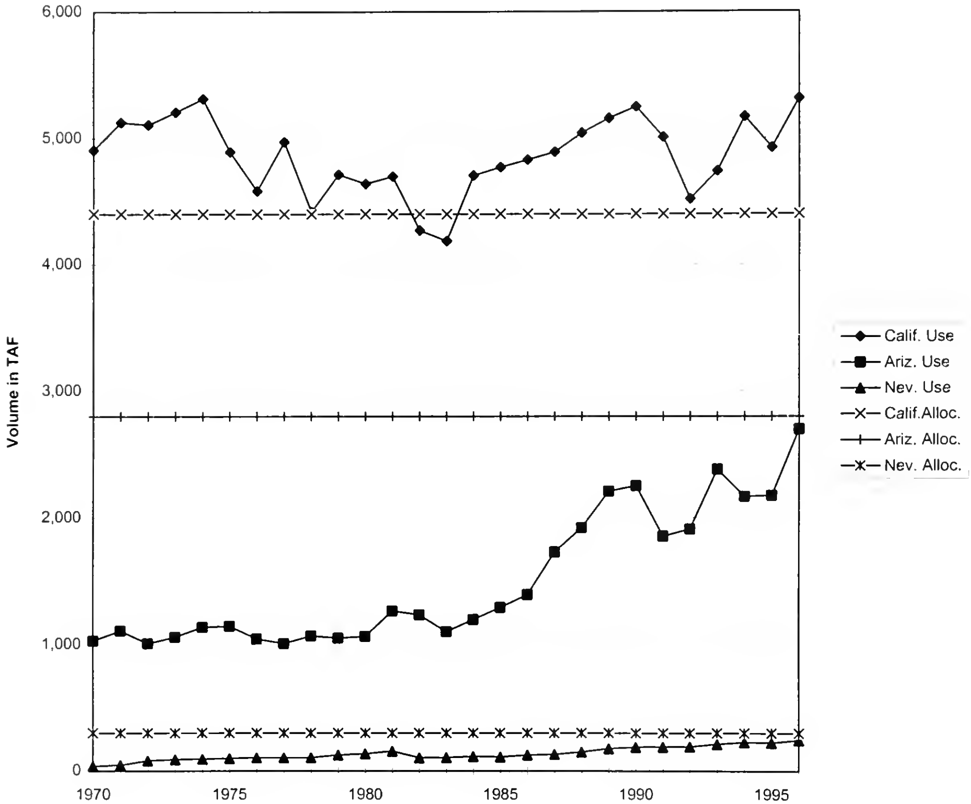


Table 9-18. Colorado River Inflow and Uses[1]

		maf per year
Average (1906-1990) Inflow		
Upper Basin		15.2
Lower Basin		1.0
	TOTAL	**16.2**
Current Uses		
Upper Basin		3.7
Lower Basin[2]		7.5
Mexico		1.5
	Subtotal	**12.7**
Basin Evaporation and Losses		**1.7**
	TOTAL	**14.4**
Average Inflow into Reservoir Storage (16.2 - 14.4)		**1.8**

[1] Prepared by the Colorado River Board of California.

[2] Reflects restriction on MWDSC's diversion as Central Arizona Project and Southern Nevada Water System diversions increase.

Supplies from Other Sources

Local agencies contracting with SWP for part of their supplies are shown in Table 9-19.

Table 9-19. State Water Project Contractors in the Colorado River Region

Agency	*Maximum Contract Entitlement (af)*	*SWP Deliveries in 1995 (af)*
Coachella Valley Water District	23,100	23,100
Desert Water Agency	38,100	38,100
Mojave Water Agency	50,800[1]	8,722
San Gorgonio Pass Water Agency	17,300	0

[1] Contract entitlement covers both South Lahontan and Colorado River regions. 7,257 af of this amount is allocated to Colorado River Region.

Neither CVWD nor DWA have facilities to take direct delivery of SWP water. Instead, both agencies have entered into an exchange agreement with MWDSC, whereby MWDSC releases water from its Colorado River Aqueduct into the Whitewater River for storage in the upper Coachella Valley groundwater basin. In turn, MWDSC takes delivery of an equal amount

of the agencies' SWP water. San Gorgonio Pass Water Agency, which serves the Banning/Beaumont area, also lacks the facilities to take delivery of SWP water, and to date has received no actual supply from the SWP. SGPWA will receive SWP supply when the Department completes its extension of the East Branch of the California Aqueduct in 1998.

Groundwater, local surface water, and wastewater reclamation provide the remaining supplies for this region. CVWD, working with DWA, has an active groundwater recharge program for the upper end of the Coachella Valley (generally, the urbanized part of the valley). CVWD recharges groundwater with imported supplies and with Whitewater River flows using percolation ponds constructed in the Windy Point area. CVWD and DWA levy an extraction fee on larger groundwater users in the upper valley.

Local Water Resources Management Issues

Management of California's Colorado River Water

The major water management issue in this region is California's use of Colorado River water in excess of its basic annual apportionment of 4.4 maf. This issue affects water users in the South Coast Region (Chapter 7) as well as those in Colorado River Region. In the past, Arizona and Nevada were not using the full amount of their basic apportionments, and California was, in accordance with the Law of the River, able to use the amount apportioned to, but not used by, Nevada and Arizona. Discussions among the seven basin states and ten Colorado River Indian Tribes over changes to Colorado River operating criteria and ways for California to reduce its Colorado River water use began as early as 1991. The drought in northern California prompted California to request that USBR make surplus water available, so that maximum use could be made of Colorado River water in southern California. These discussions over changes to reservoir operations and how surplus or shortage conditions could be established continued for a time in a forum known as the "7/10 process."

☞Photo: Rockwood canal

More recently, the California local agencies, working through the Colorado River Board, have been developing a proposal for discussion with the other basin states to illustrate how California would reduce its use to the basic apportionment of 4.4 maf. Drafts of that proposal,

referred to as California's 4.4 Plan, have been shared with the other states, and efforts are being made to reach intrastate consensus on the plan by the end of 1997.

As currently formulated, the draft plan would be implemented in two phases. The first phase would entail implementing already identified measures (such as water conservation and transfers) to reduce California's Colorado River water use to an as-yet-to-be-specified amount by some date to be specified. The second phase would implement additional measures to reduce California's use to the basic 4.4 maf amount. One of the fundamental assumptions made in the plan is that MWDSC's Colorado River Aqueduct will be kept full, by making water transfers from agricultural users in the Colorado River region to urban water users in the South Coast Region. (The Colorado River Aqueduct's capacity is a maximum of 1.3 maf per year. However, as shown in Table 9-17, MWDSC has a fourth priority right to 550 taf annually -- the remaining capacity of the aqueduct has historically been filled with water unused by other entities or with surplus water.)

In the October 1997 version of the draft plan shared with the other basin states, several specific actions were identified for the first phase, including: core water transfers (every year water transfers) such as the existing IID/MWD agreement and the proposed IID/SDCWA transfer; seepage recovery from unlined sections of the All American and Coachella Canals; drought year water transfers similar to the PVID/MWDSC pilot project; groundwater banking in Arizona; and conjunctive use of groundwater in areas such as the Coachella Valley. The actions are described in more detail below. The draft plan recognizes that transfers of conserved water must be evaluated in the context of preserving the Salton Sea's environmental resources, and also that a Colorado River wheeling arrangement would be necessary to implement the proposed IID/SDCWA transfer.

Other actions to occur as part of the first phase would include implementation of the San Luis Rey Indian water rights settlement authorized in PL 100-675 and implementation of measures to administer agricultural water entitlements within the first three priorities of the Seven Party Agreement. Examples of such measures include quantifying amounts of water conserved or transferred, and annually reconciling water use with water allocations (e.g., overrun accounting).

An important element of the draft 4.4 plan is the concept that existing reservoir operations criteria be changed to make optimum use of the river's runoff and available basin storage capacity. (See sidebar on Colorado River operations.) California agencies are presently developing new proposed operations criteria for inclusion in the 4.4 plan. The draft plan contemplates that changes in operations criteria would be part of both the first and second phases. The other basin states have been cautious in their reaction to California's proposals for reservoir reoperation, and have suggested that, for example, new criteria should not be implemented until California has prepared and executed the environmental documents and agreements that would be needed to begin implementation of the 4.4 plan.

The second phase of the 4.4 plan would include additional average year and drought year water transfers. Specifics on these transfers would be developed during phase one of plan implementation. One suggested component has been construction of desalting facilities on the New or Alamo rivers to divert and treat agricultural drainage water that would otherwise enter the sea. The treated water could be conveyed to urban water users in the South Coast Region via the Colorado River Aqueduct. As with any alternative that would reduce the amount of fresh water reaching the sea, the environmental impacts of this approach would require careful evaluation.

☞Photo: Parker Dam

Colorado River Operations

Operations of Colorado River reservoirs are controlled by the USBR, which in effect serves as the watermaster for the river. USBR is responsible for maintaining an accounting of consumptive use of the basin states' allocations, and for ensuring that Mexican treaty requirements are met with respect to the quantity of flows and salinity concentration of water delivered to Mexico.

The 1968 Colorado River Basin Project Act directed DOI to develop criteria for long-range operation of the major federal reservoirs on the river and its tributaries. USBR conducts a formal review of the long-range operating criteria every five years. The Act further requires DOI to prepare an annual operating plan for the river, in consultation with representatives from the basin states. Some reservoir operating criteria have already been established in the statutes comprising the law of the river. For example, USBR is required to equalize, to the extent practicable, storage in Lake Mead and Lake Powell. (Lake Powell, in essence, serves as the bank account that guarantees annual delivery of 7.5 maf from the Upper Basin to the Lower Basin, plus Mexican water requirements. The actual statutory guarantee is 75 maf every 10 years, plus one-half of any deficiency in Colorado River supplies, to permit the U.S. to satisfy its treaty obligation to Mexico.)

☞Photo: Hoover Dam

Current federal operating criteria for the reservoirs have focused on avoiding flood control releases, in response to the wet hydrologic conditions experienced on the river in the 1980s. As consumptive use of water in the Lower Basin has been approaching the 7.5 maf basic apportionment, there has been increasing interest in operating the reservoirs more efficiently from a water supply standpoint. Proposals discussed among Colorado River water users have included a variety of surplus and shortage operating criteria, and augmentation of the river's base flow. In order to be implemented, any changes in operating criteria formally recommended by the CRB would have to be acceptable to the other basin states and to the federal government.

USBR declared a surplus condition on the river in 1996 and 1997, allowing California to continue diverting more than its basic apportionment without penalty. In 1997, flood control releases were made from Lake Mead. Flood control releases are forecasted for 1998.

Colorado River Board of California

The Colorado River Board of California is the state agency responsible for administering California's Colorado River water allocation, and for dealing with the other basin states on river management issues. The Board is composed of six members representing the California agencies who were signatories to the 1931 Seven-Party Agreement, two public members, and two ex-officio members (the directors of DWR and DFG). The six local agencies represented on the CRB are CVWD, IID, LADWP, MWDSC, PVID, and SDCWA. CRB's office and staff are located in Glendale.

Tribal Water Rights

Colorado River Indian Tribes. As a result of the 1964 U.S. Supreme Court decree in *Arizona v. California*, California's basic apportionment of Colorado River water was quantified and five lower Colorado River indian tribes were awarded 905,496 af of annual diversions; 131,400 af of which were allocated for diversion in and chargeable to California pursuant to a later supplemental decree.

In 1978, the tribes asked the court to grant them additional water rights, alleging that the U.S. failed to claim a sufficient amount of irrigable acreage, called omitted lands, in the earlier litigation. The tribes also raised claims called boundary land claims for more water based on allegedly larger reservation boundaries than had been assumed by the court in its initial award. In 1982, the special master appointed by the Supreme Court to hear these claims recommended that additional water rights be granted to the Indian tribes. In 1983, however, the Supreme Court rejected the claims for omitted lands from further consideration and ruled that the claims for boundary lands could not be resolved until disputed boundaries were finally determined. Three of the five tribes--Fort Mojave Indian Tribe, Quechan Indian Tribe, and Colorado River Indian Tribe--are pursuing additional water rights related to the boundary lands claims. A settlement has been reached on the Fort Mojave claim and may soon be reached on the CRIT claim. Both settlements would then be presented to the special master. The Quechan claim has been rejected by the special master on the grounds that any such claim was necessarily disposed of as part of a Court of Claims settlement entered into by the tribe in a related matter in the mid-1980s. As with all claims to water from the main stem of the Colorado River and any determination by the special master, only the U.S. Supreme Court itself can make the final ruling.

If both the Fort Mojave and CRIT settlements are approved, the two tribes would each receive several thousand acre-feet of water rights in addition to the amounts granted them in the 1964 decree.

San Luis Rey Indian Water Rights Settlement Act. The San Luis Rey Indian Water Rights Settlement Act (Public Law No. 100-675; 102 Stat. 4000 [1988]) implements an agreement settling over 20 years of litigation affecting the interests of the United States, the City of Escondido, the Escondido Mutual Water Company, the Vista Irrigation District, and the La

Jolla, Rincon, San Pasqual, Pauma, and Pala Bands of Mission Indians, to provide for settlement of reserved tribal water rights claims. The litigation and proceedings before the Federal Energy Regulatory Commission involved tribal water rights claims to the waters of the San Luis Rey River and questions of the validity of rights of way granted by the U.S. across tribal and allotted lands. The Act authorizes and directs the Secretary of the Interior to arrange for a 16,000 af/year supplemental supply of water to benefit the Bands and the local communities. This supply can be obtained either from water development from public lands in California outside the service area of the CVP or from water salvaged as the result of lining part of the AAC or Coachella Canal. Title II of P.L. 100-675 authorizes the lining of part of the canals, either by the U.S. or by contract with PVID, IID, CVWD, and/or MWDSC for construction or funding.

Water Conservation and Transfers

There have been several large-scale water conservation programs involving Colorado River water users, as shown in Table 9-20.

Table 9-20. Existing Colorado River Water Conservation Programs

Year Executed	Program	Participants	Comments/Status	Estimated Savings
1980	Line 49 miles of Coachella Branch of All American Canal	USBR, CVWD, MWDSC	Project completed.	132,000 af/year
1988	IID distribution system improvements and on-farm water management actions	IID, MWDSC	Multi-year agreement, extends through 2032. Projects MWDSC has funded include canal lining, regulatory reservoir and spill interceptor canal construction, tailwater return systems, and system automation projects. MWDSC will have funded over $150 million for conservation program costs through 1997.	97,740 af/year in 1997, ultimately up to 106,110 af/yr.
1992	Groundwater banking in Arizona	MWDSC, CAWCD, SNWA	Test program to bank up to 300 taf	MWDSC and SNWA have stored 139 taf in Arizona groundwater basins.
1992	PVID land fallowing	PVID, MWDSC	Project completed. Two-year land fallowing test program. Covered 20,215 acres in PVID. MWDSC paid $25 million to farmers.	Total of 185,978 af was made available from the program, but the water use subsequently spilled from Lake Mead.
1995	Partnership agreement	USBR, CVWD	Provides, among other things, for studies to optimize reasonable beneficial use of water in the District.	N/A

☞Photo: Salton Sea

Salton Sea

The present day Salton Sea was formed in 1905, when Colorado River water flowed through a break in a canal that had been constructed along the U.S./Mexican border to divert the river's flow to agricultural lands in the Imperial Valley. Until that break was repaired in 1907, the full flow of the river was diverted into the Salton Sink, a structural trough whose lowest point is about 278 feet below sea level. Within geologic time, the Colorado River's course has altered several times. At times, the river discharged to the Gulf of California as it does today. At other times it flowed into the Salton Sink. Lake Cahuilla, the most recent of several prehistoric lakes to have occupied the Salton Sink, dried up some 300 years ago.

The Salton Sea is the largest lake located entirely within California, with a volume of about 7.7 maf. The Sea occupies a closed drainage basin -- if there were no inflows to maintain lake levels, its waters would evaporate as did those of prehistoric Lake Cahuilla. The area's average annual precipitation is 3 inches or less, while average annual evaporation is in excess of 5 feet. The Sea receives over 1 maf annually of inflow, primarily from agricultural drainage. The largest sources of inflow (about 80 percent of the total) are the New and Alamo rivers which drain agricultural lands in the Mexicali and Imperial valleys and flow into the sea's southern end. The New River also receives untreated or minimally treated wastewater flows from the Mexicali area; monitoring results generally indicate that pollution associated with wastewater discharges does not reach the Sea because of its distance from the Mexican border.

In 1924, President Coolidge issued an executive order withdrawing seabed lands lying below elevation -244 for the purpose of receiving agricultural drainage water. That order was expanded in 1928 to lands below elevation -220. The Sea supports water-based recreational activities, and has had a popular corvina fishery. During the 1950s, the highest per capita sport fishing catches in California were from the Salton Sea. Over the years, concerns about the sea's salinity have been voiced in the context of maintaining this recreational fishery with introduced species able to tolerate high salinities.

The Sea also provides important wintering habitat for many species of migratory waterfowl and shorebirds, including some species whose diets are based exclusively on the fish in the sea. Wetlands near the Sea and adjoining cultivated agricultural lands offer the avian population a mix of habitat types and food sources. An area at the Sea's south end was established as a National Wildlife Refuge in 1930, although most of that area is now underwater as a result of the Sea's rising elevation. Some of the 380 bird species wintering in the area include pelicans, herons, egrets, cranes, cormorants, ibises, ducks, grebes, falcons, plovers, avocets, sandpipers, and gulls. The Salton Sea is considered to be a major stopover point for birds migrating on the Pacific Flyway, and has one of the highest levels of bird diversity of refuges in the federal system.

Historically, salinity has been the water quality constituent of most concern at the Sea. Present levels are about 44,000 mg/l TDS (seawater is about 35,000 mg/l TDS). This high level of salinity reflects long-term evaporation and concentration of salts found in its inflow. Selenium

has been a more recent constituent of interest, due to its implications for aquatic species. Although selenium levels in the water column in the Sea are less than the federal criteria of 5 ug/l, thesecriteria can be exceeded in seabed sediment and in influent agricultural drainage water. Agricultural drain flows also contribute significant nutrient loading to the Sea, which supports large algal blooms at some times of the year. These algal blooms have contributed to odor problems and low dissolved oxygen levels in some areas of the Sea.

Over the long term, the Sea's elevation has gradually increased, going from a low on the order of -250 in the 1920s to its present level of about -226 feet. The Sea's maximum elevation in recent years was -225.6 in 1995. Since some shoreline areas are relatively flat, a small change in elevation can result in a large difference in the extent of shoreline submerged. Levees have been constructed to protect adjacent farmland and structures at some sites along the shoreline; the remaining managed acreage of the Salton Sea National Wildlife Refuge is also protected from the sea by levees.

Over the years, USBR and others have considered potential solutions to stabilize the Sea's salinity and elevation. Most recently, the Salton Sea Authority (a joint powers authority) has been performing appraisal-level evaluations of some of the frequently suggested alternatives. Categories of alternatives considered include:

- Diking off part(s) of the Sea to create evaporation pond(s) adjoining the primary water body. This approach would divert part of the Sea's water into managed impoundments, where the water would be concentrated into a brine and the salts would eventually be removed. The facilities would be sized to maintain a primary waterbody at some desired salinity concentration and elevation. The desired salinity concentration would probably be near that of ocean water (or slightly greater) to allow maintenance of the recreational fishery.
- Pumping Salton Sea water and exporting it to some other location. Possible discharge locations include nearby dry desert lakebeds (to create evaporation ponds), evaporation ponds to be constructed near the Sea, the Gulf of California, or the Laguna Salada in Mexico.
- Building treatment facilities (such as a desalting plant) to remove salts from inflows to the Sea.

- Importing fresh water to the Sea. The probable source would be the Colorado River, but only in years when flood control releases were being made in excess of U.S. needs.

Maintaining a viable Salton Sea has several water management implications. First will be the actions needed to stabilize the Sea's salinity in the near-term, such as the Authority's diking proposal. Eventually, a long-term solution will need to be developed. A wide range of costs has been mentioned for a long-term solution, including amounts in the billion-dollar range. Some of the possible long-term solutions suggested would entail constructing facilities in Mexico, bringing a greater level of complexity to their implementation. Other water management programs in the region, such as proposals to transfer conserved agricultural water supplies, will have to be evaluated in terms of their impacts on the Sea. Recent proposals to desalt water in the Alamo or New rivers and to transport that water in the Colorado River Aqueduct to the South Coast for urban water supply have raised additional concerns about maintaining the Sea's environmental productivity. (In 1997, CVWD filed an application with the SWRCB for water rights to Whitewater River flows [storm water and drainage flows] entering the Sea's northern end. MWDSC made a similar filing for agricultural drainage flowing into the Sea's southern end.)

Coachella Valley Groundwater Overdraft

Most PSAs within the Colorado River Region have sufficient water to meet future water needs, with the exception of Coachella Valley. Groundwater overdraft has occured in the upper (urbanized) part of the valley; DWA and CVWA have been managing extractions in that basin to minimize future overdraft. The availability of imported surface water at the upper end of the valley has provided a source of recharge water.

Groundwater overdraft has occurred in the lower (agricultural) portion of the valley, an area that roughly coincides with CVWD's Improvement District No.1. CVWD estimates that actual 1995 water use within the ID#1 area was about 520,000 af, part of which was supplied by overdrafting the groundwater basin. (Irrigators in the lower valley are supplied by both surface water from the Coachella Canal and by groundwater.) The district is in the process of preparing a groundwater management plan for the lower valley, and has considered alternatives including basin adjudication, water conservation, water recycling, and direct or in-lieu recharge with water imported from the Colorado River or from the SWP.

Environmental Water Issues in the Colorado River Basin

The Colorado River Basin contains a vast network of streams, canals, dams, and reservoirs; portions of which provide habitat fish species listed, or proposed for listing under the federal ESA. The listed fish species are Colorado squawfish (*Ptychocheilus lucius*); razorback sucker (*Xyrauchen texanus*); humpback chub (*Gila cypha*); and bonytail chub (*Gila elegans*). Restoration actions to protect these fish will affect reservoir operation and streamflow in the mainstem and tributaries. In addition to fish species, there are several sensitive or listed plants and animals in the basin including the bald eagle, belted kingfisher, southwestern willow flycatcher, and the Kanab ambersnail.

In 1993, USFWS published a draft Recovery Implementation Program for endangered fish in the upper Colorado River basin. The draft program included the following elements:

- protect instream flows;
- restore habitat;
- reduce negative impacts of non-native fish and sportsfish management;
- conserve genetic integrity;
- monitor habitat and populations and conduct research; and
- increase public awareness of the role and importance of native fish.

Problems facing native fishes in the mainstem Colorado River and its tributaries will not be easily resolved. For example, two fish species in the most danger of extinction, the bonytail chub and the razorback sucker, are not expected to survive in the wild. Although there was a commercial razorback fishery until 1950, in recent years most stream and reservoir fisheries in the basin have been managed for non-native fish and these management practices have harmed residual populations of natives. Many native fishes are readily propagated in hatcheries, and thus recovery programs include captive broodstock programs to maintain the species. Reestablishing wild populations from hatchery stocks will have to be managed in concert with programs to manage river habitat. For example, although 15 million juvenile razorback suckers were planted in Arizona streams from 1981-1990, the majority of these planted fish were likely eaten by introduced predators. In 1994, the states of Colorado, Wyoming, and Utah reached an agreement with USFWS on protocols for stocking non-native fish in the upper basin - a stocking protocol consistent with native fish recovery efforts.

Instream flows in the mainstem and key tributaries are being evaluated as components of native fish recovery efforts. State and federal agencies are and will be conducting studies to estimate base flow and flushing flow needs for listed and sensitive species. An example of flushing flow evaluation occurred in the spring of 1996 when releases from Glenn Canyon Dam were increased several days to attempt to redistribute sediment and create shallow water habitat in the mainstem below the dam.

In a recent court action involving the southwestern willow flycatcher, an environmental group filed a lawsuit against USBR in 1997 under the ESA's citizen suit provisions. The group alleged that USBR's operation of Lake Mead was endangering the flycatcher's habitat. The federal district court ruled in favor of USBR, but the environmental group appealed the district court's decision to the Ninth Circuit. The plaintiff's desired remedy would lower Lake Mead's water surface elevation, costing as much as 4 maf of storage. As part of its response to the litigation, USBR performed a field reconnaissance survey of flycatcher nesting areas, which identified a wide geographic range of nesting sites at Colorado River tributaries.

Lower Colorado River Multi-Species Conservation Program

In 1995, DOI executed an agreement with the LCRMSCP Steering Committee for a cooperative effort to develop a multi-species conservation program for ESA-listed species within the 100-year floodplain of the lower Colorado River. The Steering Committee is composed of representatives from California, Nevada, and Arizona, organized under a joint participation agreement. (California is represented on the committee by CRB and by DFG.) The Steering Committee has been designated as an ecosystem conservation and recovery implementation team pursuant to the ESA.

The conservation program covers USBR's Colorado River operation and maintenance actions for the lower river. Species covered in the program include the southwestern willow flycatcher, Yuma clapper rail, bonytail chub, and razorback sucker. Developing the program is estimated to take three years. Costs of program development, estimated at $4.5 million, are to be equally split between DOI and the Steering Committee. A cost-sharing agreement for the program was executed in 1996. USBR has initiated a formal Section 7 consultation with USFWS, and a five-year final biological opinion on USBR operation and maintenance activities from Lake Mead to the southern international boundary with Mexico was issued in 1997. USBR

has estimated that the cost of implementing the biological opinion's reasonable and prudent alternatives and measures could be as high as $26 million.

Water Management Options for the Colorado River Region

The reduction in California's use of Colorado River water to the basic 4.4 maf allocation reduces the supply available to California by as much as 0.9 maf compared to historic use. A mixture of water management options will be needed to make up California's reduced supply from the Colorado River. Categories of options under consideration to achieve this goal are discussed below (see Table 9-21) and include water transfers/conservation within California, interstate transfers and banking, reoperating Colorado River system reservoirs, increasing SWP supply reliability, and augmenting Colorado River base flows (i.e., weather modification). (Options for meeting the South Coast region's water shortages as a result of reduced Colorado River supplies are also discussed in the South Coast Region water management plan in Chapter 7.) One assumption included in the options analysis is that MWDSC's Colorado River Aqueduct would remain at full capacity, because there is an existing reliance on this supply in the South Coast Region. The water to provide the additional increment of aqueduct supply would come from sources such as the options discussed below. The water could be acquired by water purveyors in the South Coast Region that are able to arrange for conveyance or exchanges from the Colorado River Region to the South Coast Region.

Potential Sources of Water for Intrastate Transfers

The ability to transfer conserved water has already been demonstrated in the region, as described previously. Table 9-22 summarizes some potential sources of water for intrastate transfers. Such transfers could make up some of the shortages in the South Coast Region resulting from California reducing its use to California's basic apportionment of 4.4 maf.

Table 9-21
Comprehensive List of Options
Colorado River Region

Category	Option	Retain or Defer	Reason for Deferral
Conservation			
Urban			
	Outdoor Water Use to 0.8ETo	Retain	
	Residential Indoor Water Use	Retain	
	Interior CII Water Use	Retain	
	Distribution System Losses	Defer	No substantial depletion reductions attainable.
Agricultural			
	Seasonal Application Efficiency Improvements	Retain	
	Flexible Water Delivery	Retain	
	Canal Lining and Piping	Retain	
	Tailwater Recovery	Retain	
Modify Existing Reservoirs/Operations			
	Reoperating Colorado River System Reservoirs	Defer	No generally accepted proposal available for quantification.
New Reservoirs/Conveyance Facilities			
	Additional Conveyance Capacity for Colorado River Water	Defer	California's current excess use of Colorado River water.
Groundwater/Conjunctive Use			
	Groundwater Recharge Project at East Mesa	Defer	Limited-term program.
Water Transfers/Banking/Exchange			
	Interstate Banking	Retain	
	Land Fallowing Program	Retain	
	MWDSC Exchange Water	Defer	Currently only in preliminary stages of discussion.
Water Recycling			
	---	---	---
Desalination			
Brackish Groundwater			
	---	---	---
Seawater			
	---	---	---
Other Local Options			
	Lining the All American Canal / Well Fields	Retain	
	Additional Lining of Coachella Canal	Retain	
	Weather Modification	Defer	Complicated by interstate management issues.
Statewide Options			
	CALFED Bay / Delta Program	Retain	
	SWP Interim South Delta Program	Retain	
	SWP Supplemental Water Purchase Program	Retain	
	Enlarge Shasta Lake	Retain	

Table 9-22. Potential Colorado River Water Conservation Programs

Year	Program	Participants	Comments/Status	Estimated Savings
1988	Lining of All American Canal	USBR, IID CVWD, MWDSC	Authorized by PL100-675. Final EIS published and Record of Decision signed in 1988. Preferred alternative is constructing a new, lined parallel canal, rather than lining existing canal. Another alternative is well field construction.	Not implemented yet. Potential of 67,700 af/yr.
1995	MOU to negotiate terms and conditions of a long-term transfer of up to 200,000 af/year	IID, SDCWA	Participants have developed initial draft terms and conditions, and have distributed them for public review. Program contingent on SDCWA and MWDSC reaching agreement on arrangements to wheel water in MWDSC's Colorado River Aqueduct and distribution system.	Not implemented yet - under negotiation.
Not executed	Additional lining of Coachella Canal	USBR, others	Authorized by PL100-675. Draft EIR/EIS issued. Further work was deferred due to cost of project, but project is being reconsidered.	25,680 af/yr

Construction of additional conveyance capacity from the Colorado River Region to the South Coast area has been a recent subject of discussion. Proposition 204 provides funding for a feasibility study of a new conveyance facility from the Colorado River to the South Coast Region. Conveyance facilities mentioned include a new aqueduct from the Imperial Valley area to San Diego, as well as San Diego's participation in enlarging the existing aqueduct serving Tijuana, Mexico. A preliminary engineering study of constructing a canal from IID to San Diego has been prepared for SDCWA. Considerable additional work, including geotechnical exploration and environmental studies, would be needed to evaluate the project's feasibility. Of particular interest, the preliminary study highlighted the need to evaluate desalting the water that the aqueduct would supply to enable San Diego's continued reliance on a high level of wastewater reclamation. New conveyance facilities from the Colorado River region to the South Coast Region have been deferred from evaluation in Bulletin 160-98 because it does not appear that they would be constructed within the Bulletin's planning horizon, especially given the other basin states' concerns about California's use of Colorado River water.

SDCWA and IID have been discussing a potential transfer of water saved due to extraordinary conservation measures within IID. The agencies executed a September 1995 MOU concerning negotiation of a transfer agreement, to be followed by development of proposed terms and conditions of a transfer. Terms and conditions for a proposed agreement with a 75-year term have been distributed for review to the agencies' water users and interested parties. As proposed, an initial transfer of 20 taf would begin in 1999, with the annual quantity of transferred water increasing to 200 taf after 10 years. In order to transfer the acquired water, SDCWA (a member agency of MWDSC) must negotiate a wheeling agreement with MWDSC for use of capacity in MWDSC's Colorado River Aqueduct. Discussions between SDCWA and MWDSC have been ongoing.

Past conservation projects in the region have included land fallowing, canal lining, distribution system reservoir and spill interceptor canal construction, and irrigation distribution system improvements. Some proposed projects to recover canal seepage include:

- ***Lining part of the All American Canal.*** Public Law 100-675 authorized the Secretary of the Interior to line the canal or to otherwise recover canal seepage, using construction funds from PVID, IID, CVWD, or MWDSC. In March 1994, the USBR completed an EIS/EIR, which evaluated a parallel canal alternative, several in-place lining alternatives, and a well field alternative. The EIS/EIR concluded that the preferred alternative was the construction of a concrete-lined canal parallel to 23 miles of the existing canal. The parallel canal alternative has the potential to annually conserve an estimated 67,700 af of Colorado River water. Environmental documentation has been completed and a Record of Decision has been signed. Recently, interest in the well field alternative has increased. (Originally, the well field alternative, although less expensive than canal lining, had been set aside because of international concerns about groundwater extraction near the border.)
- ***Lining the Remaining Section of the Coachella Canal.*** This project would involve lining the remaining 33.4 miles of the Coachella Canal, which loses about 32,350 af of water per year through seepage. Four alternatives that have been identified are conventional lining, underwater lining, parallel canal, and no action. It is estimated that the preferred alternative, conventional lining, would conserve 25,680 af/yr.

Other Conservation Actions

Urban. The urban water supply forecasts for 2020 assume that BMPs are in place; consequently, only those urban conservation efforts which exceed BMPs are considered as options. All urban conservation options were retained. Reducing outdoor water use to 0.8 ETo in new development would attain about 20 taf per year of depletion reductions, while extending this measure to include existing development would reduce depletions by about 40 taf per year. Reducing indoor water use to 70 gpcd and 65 gpcd would reduce depletion by 10 and 20 taf per year, respectively. Reducing commercial, institutional, and industrial water use by 2 percent and 3 percent would attain 2 taf and 4 taf of depletion reductions per year, respectively. Reducing distribution system losses would result in less than 1 taf per year of depletion reductions.

Agricultural. As with the urban water management options, only those agricultural conservation efforts which exceed EWMPs are considered as options. Improving seasonal application efficiency to 80 percent from the base of 73 percent could reduce depletions by 50 taf; while improving flexible water delivery, canal lining (on-farm and distribution system), and tailwater recovery systems could together realize 140 taf in depletion reductions. However, the ability to implement conservation options that would reduce the amount of fresh water inflow to the Salton Sea must be evaluated on a project-specific basis. Goals for preservation of the Sea's environmental resources may limit the extent of feasible conservation measures.

Intrastate Groundwater Recharge or Banking

IID has proposed a groundwater recharge project at East Mesa in the Imperial Valley. The proposed recharge project would divert a portion of flood control releases from Lake Mead to a recharge site or sites located along the alignment of the old, unlined Coachella Branch of the AAC. (The old canal was abandoned when an adjacent lined canal was constructed.) IID estimates that up to 20 taf could be recharged in 1998. IID has prepared a draft, mitigated negative declaration for a one-time program in 1998, when flood control releases are expected. Since Colorado River flood control releases have historically been infrequent, future water supply for such a recharge program would be available only occasionally. We have deferred consideration of this option as a future water management action because it was scoped as a one-time project.

Interstate Banking/Conservation

Prior Banking. Under an agreement between MWDSC and the Central Arizona Water Conservation District, MWDSC stored unused Colorado River water in Arizona between 1992 and 1995. The Southern Nevada Water Authority has also participated in the program. Under the agreement, up to 300 taf can be stored in central Arizona through December 31, 2000. To date, MWDSC has placed 89 taf and SNWA has placed 50 taf in storage for a total of 139 taf. About 90 percent of the stored water can be recovered.

Future Banking. In its 1996 session, the Arizona Legislature enacted HB 2494, establishing the Arizona Water Banking Authority. The Authority is authorized to purchase unused Colorado River water and to store it in groundwater basins to meet future needs. Conveyance to storage areas is provided by the Central Arizona Project. The legislation further provided that the Authority may enter into agreements with California and Nevada agencies to bank water in Arizona basins, with the following limitations.

1) Regulations governing interstate banking would need to be promulgated by the Secretary of the Interior and the Arizona Department of Water Resources.
2) ADWR finds that DOI's regulations adequately protect Arizona's rights to Colorado River water.
3) The ability to bank interstate water would be subordinate to banking of water to supply Arizona needs.
4) Interstate banking would be precluded in years when Arizona is using its full apportionment of 2.8 maf (including water being delivered to Arizona for banking by Arizona agencies), unless surplus conditions were declared on the river system.
5) Interstate withdrawals from the bank are limited to 100 taf per year, although there is no statutory limitation on annual deposits.

Under this legislation, future interstate banking in Arizona would have a maximum drought year yield of 100 taf, with 50 taf being available to California (assuming 50 taf would be available to Nevada). However, Arizona may effectively limit withdrawals in drought years by declining to decrease its diversions of surface water that would allow recovery of the banked water.

Land Fallowing Programs

Land fallowing programs such as the Palo Verde test land fallowing program discussed in Chapter 7, could be implemented to provide water for transfer to urban areas in the South Coast Region during drought periods.

Reoperating Colorado River System Reservoirs

Member agencies represented at the Colorado River Board of California have discussed establishing new river operations criteria that would benefit California while protecting the apportionments of the other basin states and satisfying Mexican treaty obligations. Such criteria would also constitute part of the package of actions for California to transition its use of river water from current levels to 4.4 maf per year. Operations studies have evaluated specific shortage and surplus criteria for the river system, including selection of desired probabilities for water supply reliability and reservoir operating elevations.

Results of the operations studies performed by CRB and by USBR suggest that there would be no hydrologic impediment to using reservoir reoperation -- particularly as a limited-term measure to help California reduce its Colorado River use -- as a water management option for this region. As described in Chapter 3, the Colorado River has a high ratio of storage capacity to average annual runoff. Projections of consumptive use for the upper basin states suggest that those states will not attain full use of their compact apportionments until after year 2060. USBR's surplus declarations to date have not adversely impacted the other states' use of their apportionments -- for example, flood control releases were made in 1997, and are expected in 1998. The more significant impediment to implementing reoperation would be the concerns of the other basin states about impacts of an extended period of reoperation on the ability to avoid future shortages, considering the river's variable year to year runoff.

For this bulletin, reservoir reoperation is not evaluated as a water management option and no numerical evaluation is made, since there is presently no generally accepted proposal available for quantification.

Water Augmentation (Weather Modification)

One of the fundamental management issues associated with Colorado River water supplies is the apparent overstatement of the Compact apportionment relative to the river's historic hydrology. There have been a variety of proposals over the years to augment the river's

base flow to provide additional supplies. For example, USBR had developed a proposed pilot program in 1993 to evaluate cloud seeding potential in the upper basin. The state of Colorado did not favor moving ahead with this program.

Weather modification has recently been raised again as part of a possible menu of options to resolve California's use in excess of the 4.4 maf basic apportionment, although no specific proposals have been made. In concept, this option would entail cloud seeding in the Upper Basin to increase runoff, and might yield a 5 percent increase in base flow if a large area of the upper basin were seeded. Large-scale weather modification projects are typically difficult to implement due to institutional and third-party concerns, and can require several years of study and testing prior to being placed in operational status. Weather modification on the Colorado River is also complicated by interstate management issues. This option has been deferred for these reasons.

Options for Coachella Valley

Conjunctive Use Programs. MWDSC and CVWD may agree to store water conserved from the existing MWD/IID conservation program (or surplus Colorado River water, if available,) in the Coachella Valley groundwater basin for extraction for MWDSC's use in drought years. Coachella Valley users could be protected by ensuring that MWDSC recharged more water than it would be entitled to extract. This would be in addition to the current agreement that MWDSC has with CVWD for advance delivery of Colorado River water in exchange for SWP supply. Conveyance of this water to CVWD's groundwater basin would need to be negotiated. Alternatively, MWDSC and CVWD could negotiate an agreement to store additional supplies conveyed by the SWP. Likewise, other agencies with Colorado River supplies could negotiate similar agreements. This concept is in the preliminary stages of discussion and is deferred from further analysis here because potential options have not yet been quantified.

Purchase Additional SWP Water/Transfers Conveyed by SWP. CVWD could, as other SWP urban water contractors are doing, participate in the permanent transfer of agricultural entitlement water provided for in the Monterey Agreement contract amendments. CVWD could also purchase water from other sources, by way of exchange with MWDSC, subject to negotiation of conveyance in the SWP and CRA. Since no specific proposals are currently pending, we have not quantified this option in the Bulletin.

Statewide Options

Active planning for statewide water supply options is currently being done for the CALFED Bay-Delta Program and for SWP future supply. Improving the water supply reliability of supplies conveyed across the Sacramento-San Joaquin River Delta provides a significant improvement in supply reliability to urban water users in the South Coast Region. To the extent that demands in the South Coast Region are satisfied from northern California supplies, there will be less pressure on use of Colorado River supplies for that region. It is estimated that proposed Delta and SWP improvements would provide about 5,000 af to the Colorado River Region, and over 300,000 af to the South Coast Region. See Chapter 6 for discussion on statewide water supply augmentation options. *[The following text on statewide supplies is in part a placeholder for potential outcomes of CALFED process. Text will be changed as CALFED results become available.]*

CALFED Bay-Delta Program. For illustrative purposes, assuming improved Delta conditions through the implementation of CALFED alternatives, additional SWP yield to the region could be 2,000 af in average and drought years.

State Water Project Improvements. DWR has two programs underway which could improve SWP yields to its contractors in the Colorado River Region. The programs are discussed in Chapter 6. The ISDP would augment SWP supplies to the region by 3,000 af in average and drought years. The Supplemental Water Purchase Program could potentially provide an additional 3,000 af in drought years.

Enlarged Shasta Lake. Enlarging Shasta to 13 maf of storage would increase drought year yield by about 1.5 maf. If we assume one-third of this yield is allocated to the environment, and the remaining two-third is allocated among the State and federal projects, the Colorado River Region could potentially receive about 8 taf per year.

Water Resources Management Plan for the Colorado River Region

Apart from groundwater overdraft in the Coachella Valley, there are no water shortages in this hydrologic region. However, the reduction in California's Colorado River water use from 5.3 maf to 4.4 maf creates an average year shortage of up to 0.56 maf in the South Coast Region. This year 2020 shortage is shown in the South Coast Region water budget, but options for

addressing the South Coast shortage that involve changes to water management in the Colorado River Region are also described in this section. Evaluation of options for Coachella Valley and the Colorado River 4.4 plan are shown in Table 9A-3 in Appendix 9A and the results are presented in Table 9-23. The following plan identifies actions that could be taken in the Colorado River Region to address Coachella Valley overdraft and to provide supplies for the South Coast Region.

Table 9-24 summarizes the actions most likely to be implemented by 2020 to meet forecasted shortages. Urban agencies in the South Coast Region that exercise Colorado River water conservation and transfer options will probably choose to exercise some options only in dry years, depending on the status of their imported water supplies from northern California.

As shown in Table 9-24, urban conservation and statewide options for the region could develop 47 taf of water to address Coachella Valley's overdraft. The readily quantifiable options for the Colorado River 4.4 Plan which can be developed amount to 284 taf in average years and 434 taf in drought years. Assuming that enough water remains within the region to address the remaining shortages in the region (32 taf and 41 in average and drought years, respectively), 252 taf and 393 taf are potentially available for transfer to the South Coast Region in average and drought years, respectively.

There remain, however, other options available to the South Coast Region that cannot be quantified at this time, such as the reoperation of Colorado River storage reservoirs. The other basin states have indicated that they are unwilling to approve changes to existing river operations criteria until they are satisfied that California has a firm plan in place to reduce its Colorado River water use to the state's basic apportionment. The local agencies represented on California's Colorado River Board are attempting to develop such a plan.

Table 9-23. Colorado River Region Options Evaluation

Option	Rank	Cost per af ($)	Potential Gain (taf) Avg	Potential Gain (taf) Drt
Conservation				
Urban				
Outdoor Water Use - New Development	M	500	20	20
Outdoor Water Use -New and Existing Development	L	*	40	40
Residential Indoor Water Use (70gpcd)	M	400	10	10
Residential Indoor Water Use (65gpcd)	M	600	20	20
Interior CII Water Use (2%)	M	500	2	2
Interior CII Water Use(3%)	L	750	4	4
Agricultural				
Seasonal Application Efficiency Improvements (76%)	H	100	10	10
Seasonal Application Efficiency Improvements (78%)	M	250	30	30
Seasonal Application Efficiency Improvements (80%)	M	450	50	50
Flexible Water Delivery	M	1,000	30	30
Canal Lining and Piping	M	1,200	45	45
Tailwater Recovery	M	150	65	65
Water Transfers/Banking/Exchange				
Interstate Banking	M		-	50
Land Fallowing Program	M		-	100
Other Local Options				
Lining the All American Canal / Well Fields	H	120	68	68
Additional Lining of Coachella Canal	H		26	26
Statewide Options				
CALFED Bay / Delta Program	M		2	2
SWP Interim South Delta Program	M	100	3	3
SWP Supplemental Water Purchase Program	L	175	-	3
Enlarge Shasta Lake	M		8	8

* Data not available

Table 9-24. Summary of Options Most Likely to be Implemented by 2020 Colorado River Region

Option	*Potential Gain (taf)*	
	Avg	*Drt*
Shortage	79	**88**
Conservation (Urban)	42	42
Statewide Options	5	5
Total Potential Gain	**47**	**47**
Remaining Shortage	**32**	**41**
Options for Colorado River 4.4 Plan		
Conservation (Agricultural)	190	190
Water Transfers/Banking/Exchange	-	150
Other Local Options	94	94
Total Potential Gain	**284**	**434**
Less Options to Reduce Remaining Shortage in Region	**(32)**	**(41)**
Remaining Shortage	**0**	**0**
Total Options for CR 4.4 Plan	**252**	**393**

Water Supply

The State's 1995 level average water year supply is about 77.1 maf. Even assuming a reduction in Colorado River supplies to California's 4.4 maf basic apportionment, average year statewide supply is projected to increase 0.58 maf by 2020 without additional water supply options. While the projected increase in water supply is due mainly to higher CVP and SWP deliveries (in response to higher 2020 level demands), additional groundwater extraction and facilities now under construction will also provide new supplies.

The State's 1995 level drought year supply is about 59.1 maf. Drought year supply is projected to increase 0.27 maf by 2020 without additional future water supply options, for the same reasons that average year supplies are expected to increase.

Bulletin 160-98 estimates a statewide groundwater overdraft of about 1.5 maf per year at a 1995 level of development, a slight increase from the Bulletin 160-93 1990 base year value. Increasing groundwater overdraft is a reversal from the trend of the 1980s. The increase in groundwater overdraft (which occurred mainly in the San Joaquin and Tulare Lake regions) from Bulletin 160-93's 1990 base year was due primarily to Delta export restrictions associated with the SWRCB's Order WR 95-6 and reductions in CVP supplies.

Water recycling continues to be a small, yet growing, element of California's water supply. At a 1995 level of development, water recycling produces about 0.32 maf per year of new water (reclaiming water that would otherwise flow to the ocean or to a salt sink), up significantly from the 1990 annual supply (0.17 maf) reported in Bulletin 160-93. Greater production at existing treatment plants and additional production at plants currently under construction are expected to increase new recycled supplies to 0.47 maf per year by 2020.

Water Demand

California's estimated demand for water at a 1995 level of development is 78.7 maf in average years and 64.3 maf in drought years. California's water demand in 2020 is forecasted to reach 80.6 maf in average years and 66.4 maf in drought years.

California's population is forecasted to increase to 47.5 million people by 2020 (about 15 million people more than the 1995 base). Even with extensive water conservation, urban water demand will increase by about 3.2 maf in average years. Forty-five percent of the State's population increase is expected to occur in the South Coast region.

Irrigated crop acreage is expected to decline by 330,000 acres -- from the 1995 level of 9.52 million acres to a 2020 level of 9.19 million acres. Reductions in forecasted irrigated acreage are due primarily to urban encroachment onto agricultural land and land retirement in the western San Joaquin Valley. Increases in water use efficiency combined with reductions in irrigated agricultural acreage are expected to reduce average year water demand by about 2.3 maf in 2020.

Average water year needs for environmental use are forecasted to increase by about 0.9 maf by 2020. This forecasted increase is due primarily to CVPIA instream flow needs and refuge water supply needs in the Sacramento and San Joaquin River regions. Drought year environmental water needs are considerably lower than average year environmental water needs, reflecting the variability of natural flows in North Coast wild and scenic rivers.

Because much of the environmental water demand is brought about by legislative or regulatory processes, forecasting environmental water demand is subject to much uncertainty. Bulletin 160-93 used a range of 1 to 3 maf to represent future environmental demands, reflecting the uncertainty of the direction of Bay-Delta regulatory actions at the time the Bulletin was published. (With the subsequent signing of the Bay-Delta Accord, Delta outflow requirements are now quantified in SWRCB's Order WR 95-6.) Implementation of CVPIA and SWRCB's Bay-Delta Plan, new ESA restrictions, and FERC relicensing/electric utility deregulation are actions that could significantly modify environmental demands within the Bulletin 160-98 planning period.

Water Shortages

Californians are facing water shortages now, as well as in the future. The shortage shown in Table 10-1 for 1995 average water year conditions reflects Bulletin 160-98's inclusion of groundwater overdraft as a shortage in the base year. As Californians experienced during the most recent drought, and especially in 1991 and 1992, drought year shortages are large. Urban residents faced cutbacks in supply and mandatory rationing, some small rural communities saw their wells go dry, agricultural lands were fallowed, and environmental water supplies were reduced. By 2020, without additional facilities and programs, these conditions will worsen, reflecting California's forecasted population increase.

Water shortages vary widely from region to region. For example, the North Coast, San

Francisco and North Lahontan regions are not expected to experience future shortages during average water years, but will see shortages in drought years. The State's remaining regions experience average and drought year shortages now, and are forecasted to experience continued shortages in 2020. The largest future shortages are forecasted for the Tulare Lake and South Coast regions, both areas that rely heavily on imported water supplies. Table 10-2 shows forecasted shortages by hydrologic region, assuming that no new facilities or programs are implemented.

Table 10-2. Water Shortages by Hydrologic Region (taf)

Region	1995		2020	
	Average	Drought	Average	Drought
North Coast	0	177	0	194
San Francisco Bay	0	349	0	376
Central Coast	214	282	177	273
South Coast	0	568	728	1295
Sacramento River	111	867	206	1109
San Joaquin River	239	788	805	1481
Tulare Lake	870	1862	735	1866
North Lahontan	0	128	10	128
South Lahontan	89	92	184	210
Colorado River	69	95	79	88
Totals (rounded)	**1,590**	**5,210**	**2,920**	**7,020**

South Coast Region shortages reflect forecasted population growth, plus lower Colorado River supplies as California reduces its use of Colorado River water to the State's basic apportionment. Tulare Lake Region shortages reflect the region's extensive agricultural development and limited local sources of water supply. Shortages in the Sacramento River and San Joaquin River regions include CVPIA supplemental fish and wildlife water needs. To the extent that these needs are met by reducing other water uses (i.e., transfers of developed water supply) those other demands would be reduced, thereby reducing the regions' shortages.

Reliable water supplies are important to California's economy and its environment. Californians cannot afford to sustain future water shortages of this magnitude. The State is

fortunate in having an extensive water supply infrastructure already in place, one that enables water conveyance to many locations and facilitates water transfers and exchanges. California's water purveyors have recognized the need to plan for the future, and many are already working on ways to build on existing water supplies while at the same time maintaining valuable environmental resources.

Recommended Options to Meet Future Demands

The actions summarized in this section represent a snapshot of the plans that water purveyors have for meeting future needs. This material relies heavily on actions identified by local water agencies, which collectively provide about 70 percent of the State's developed water supply. As described in the preceding four chapters, selection of water management options most likely to be implemented was based on a ranking process that evaluated, at an appraisal level, factors such as technical feasibility, cost, and environmental considerations. This process is most effective in hydrologic regions where local agencies have relatively recently prepared plans for meeting future needs in their service areas.

Since the focus of the Bulletin 160 series is on water supply, the statewide level plan has not been tailored to meet other water-related objectives such as flood control, hydropower generation, recreation, and nonpoint source pollution control. In the evaluation process used to selected options most likely to be implemented, the scores assigned to the options did reflect their ability to provide multiple benefits. The accompanying sidebar discusses the relationship of water supply and flood control needs, a subject receiving increasing attention in response to the January 1997 floods.

Multipurpose Facility Considerations

As discussed in Chapter 6, Bulletin 160-98 focuses on evaluation of water supply benefits of potential options. The January 1997 floods demonstrated that Central Valley flood protection needs improvement. The 1997 *Final Report of the Governor's Flood Emergency Action Team* identified many actions that could be taken to improve flood protection in the Valley, including: better emergency preparedness, floodplain management actions, levee system improvements, construction of new floodways, temporary storage of floodwaters on wildlife refuges, reoperation or enlargement of existing reservoirs to increase flood storage, and construction of new reservoirs. These latter two actions have implications from a water supply standpoint. Reoperating existing reservoirs to provide greater flood control storage usually comes at the expense of water supply. Reoperation is particularly problematical in the San Joaquin River Basin, where water supplies are already limited.

The existing Folsom Reservoir reoperation program illustrates the magnitude of operational changes that can be entailed. The 1 maf reservoir has a normal winter flood control reservation of 400 taf (estimated to provide the Sacramento area with protection from a storm having a 1-in-63-year return period). SAFCA's purchase of up to 270 af of additional winter flood control space only increases the level of protection to a 1-in-85-year event. As California's population continues to increase and more demands are place on existing water supplies, reservoir reoperation will become increasingly difficult to implement. In contrast, enlarging reservoirs or constructing new reservoirs can have water supply benefits.

Summary of Options

California should be able to meet its future water service reliability needs through a variety of local and statewide water management options, while protecting and enhancing fish and wildlife habitats. Table 10-3 provides a summary of recommended options by category. Many of the recommended options will require large commitments of funds to implement and maintain them over time.

Table 10-3. California Water Plan 2020 Options Summary By Category (maf)

Options	Average	Drought
Local Demand Management Options	**0.438**	**0.474**
Local Supply Augmentation Options	-----	-----
Surface Water	0.243	0.448
Groundwater	0.002	0.683
Transfer/Banking/Exchange	0.039	0.239
Recycling & Desalt	0.256	0.357
Statewide Options	-----	-----
CALFED	0.280	0.330
State Water Project	0.151	0.155
Drought Water Bank	----	0.250
Land Retirement	0.065	0.065
Multipurpose Reservoir Projects	0.070	0.075
Total Options	**1.54**	**3.08**

The recommended options in Table 10-3 include 0.44 maf/yr of water conservation options (0.47 maf per year under drought conditions). These water conservation options are in addition to base amounts of urban and agricultural conservation incorporated in 2020 demand forecasts. Bulletin 160-98 assumes that water agencies statewide will implement urban BMPs and agricultural EWMPs by 2020, resulting in a 2020 demand reduction of 2.3 maf annually. The water conservation options shown here are in addition to that amount, and are options that would produce new water supply through reduction of depletions.

Recommended local supply augmentation options comprise the largest potential new source of water for the State. (These local options include implementation of California's "4.4 Plan" to reduce its use of Colorado River water to the State's basic apportionment.) In this table and in the water budgets, only those water transfers are quantified where the gaining and losing regions can be identified. (Water transfers within a hydrologic region, although representing a change in type of water use, do not affect the overall water budget for the region.) Considerably more transfers have been described in the text of the four preceding chapters than are shown in the budgets, reflecting many local agencies' plans to seek future transfers from sources yet to be identified. Where the participants in a proposed transfer are known, the giving region's average

year or drought year supply has been reduced in the water budgets. Presently, the only transfers that fit this category and are large enough to be visible in the water budgets are those associated with the Colorado River 4.4 Plan.

Recommended statewide options include actions that could be taken by CALFED to develop new water supplies. As discussed earlier, the water supply benefits shown for the CALFED Bay-Delta program's preferred alternative are a placeholder at this time, until CALFED completes its final program environmental document for a Bay-Delta solution. The CALFED placeholder does not address specifics of which upstream of Delta storage facilities might be selected, or how conjunctive use programs might be operated. CALFED information will be updated in the final version of the Bulletin.

Other recommended statewide options include specific projects to improve SWP water supply reliability, the Department's drought water bank, land retirement on the westside of the San Joaquin Valley, and two multipurpose reservoirs. A third potential multipurpose reservoir option, an enlarged Shasta Lake, was not included in our list of options most likely to be implemented because further studies are needed to quantify the water supply and flood control benefits associated with different potential reservoir sizes. We do recommend additional evaluation of this option. Some cursory evaluations of an enlarged Shasta Lake are being performed now and may be available in time for an expanded discussion on enlarging Shasta Lake in the final version of Bulletin 160-98.

The two multipurpose reservoir projects included as recommended statewide options -- Auburn Reservoir and enlarged Millerton Lake (Friant Dam) -- were included in the plan to recognize the interrelationship between water supply needs and the Central Valley's flood protection needs. Both reservoir sites were ranked in the medium category from a water supply standpoint. But, as discussed in Chapter 6, each offers significant flood protection benefits. It is recognized that both projects may have controversial aspects and that neither of them is inexpensive. However, they offer enough benefits to justify serious consideration. The lead time for planning and implementation for any large reservoir project is long, and it would take almost to this Bulletin's 2020 planning horizon for the projects to be constructed.

The two multipurpose reservoir projects contrast with the other statewide options in that the identity of the specific entity(ies) that might implement them is uncertain. USBR, as the

owner of the existing Friant Dam and as the federal agency having authorization for operating Auburn, would presumably be a participant. The implementing entity could be a partnership of some combination of federal/state/local agencies.

The multipurpose reservoir projects' water supply was allocated among potentially participating hydrologic regions, to illustrate how the supplies might be used. Because the San Joaquin River system is oversubscribed with respect to the demands placed upon it, as described in the Resources Agency's 1995 *San Joaquin River Water Management Plan*, Friant's potential supply was shown as remaining in the San Joaquin River Region. For Auburn, the supply was divided between the Sacramento River and San Joaquin River regions, areas where the water could be conveyed (or supplied by exchange) to water users served by CVP facilities. Auburn could also provide supplies for additional small foothill communities that are too small to develop projects on their own, as was discussed in Chapter 8. (In neither option is it assumed that the CVP (or SWP) would contract for the supply -- only that conveyance facilities exist to make the water available to potential users.) The Bulletin makes no attempt to allocate costs of these projects between flood protection and water supply.

As discussed in Chapter 6, CVPIA supplemental fishery water supply needs (and Level 4 refuge water supply needs) were included in the Bulletin's forecasted future environmental water needs. The amounts used were identified in USBR's draft CVPIA PEIS, although they are a placeholder at this time, since decisions have not yet been made with respect to the draft PEIS. These supplemental water needs would be met by voluntary water transfers. Since no long-term arrangements for acquiring this water have yet been established, it is not possible to identify specifically how and where the supplemental water would be obtained in the future, or what other water demands might be reduced as a result of CVPIA water transfers.

Statewide Overview

The statewide plan shown in Table 10-4 was developed by combining the regional water management plans for each of the State's ten hydrologic regions. The plan illustrates the results of implementing likely water management options by 2020. (Tables 10A-11 through 10A-20 in Appendix 10A show the regional water budgets with option implementation.)

Table 10-4. California Water Budget with Recommended Options (maf)

	1995		2020	
Demands & Supplies	*Average*	*Drought*	*Average*	*Drought*
Demands				
Urban	8.773	9.009	12.017	12.356
Agriculture	33.775	34.538	31.501	32.333
Environmental	36.104	20.799	37.043	21.734
Management Options	-------	------	(-0.503)	(-0.539)
Total Demands	**78.65**	**64.35**	**80.06**	**65.88**
Supplies				
Surface Water	64.242	43.021	64.578	43.027
Groundwater	12.493	15.784	12.591	15.906
Recycled & Desalted	0.324	0.333	0.469	0.470
Augmentation Options	-------	-------	1.041	2.537
Total Supplies	**77.06**	**59.14**	**78.68**	**61.94**
Demands minus Supplies (Shortage)	**1.59**	**5.21**	**1.38**	**3.94**

This table shows that drought year shortages are much greater than average year shortages, and that water management options now under consideration by water purveyors throughout the State do not reduce either average water year or drought year shortages to zero in 2020.

Bulletin 160-98 environmental water demands include 877 taf of supplemental water identified in USBR's draft CVPIA PEIS as potentially being needed for CVPIA fish doubling goals and refuge water supplies. This 877 taf of supplemental water represents over half of the forecasted 2020 average water year shortage.

The difference between average water year and drought year water shortages can be significant. Water purveyors generally consider shortages in average years as basic deficiencies that should be corrected by implementing long-term demand reduction or supply augmentation measures. Shortages in drought years may be managed by these long-term measures, in combination with short-term actions designed to be implemented only during droughts. Such short-term measures could include purchases from the Department's drought water bank, urban water rationing, or agricultural land fallowing. Agencies may evaluate the marginal costs of

developing new supplies and may conclude that the costs of their development exceeds the costs of shortages to their service areas, or exceeds the costs of implementing contingency measures, such as transfers or rationing.

Ability to pay is another consideration. Large urban water agencies frequently set high water service reliability goals, and are able to finance actions necessary to meet the goals. Agencies supplying small rural communities may not be able to afford capital- intensive projects. Small communities have limited populations over which to spread capital costs and may have difficulty obtaining financing. If local groundwater resources are not adequate to support expected growth, these communities may not be able to afford options such as a new pipeline to bring in a surface water supply, or a seawater desalting plant. Small rural communities that are geographically isolated from population centers cannot readily interconnect with other water systems.

Agricultural water agencies may have a lesser ability to pay for capital improvements than do urban water agencies. Much of the State's earliest large-scale water development was for agriculture, and the irrigation works were constructed at a time when water development was inexpensive by present standards. Today's users of these facilities may not be able to compete with urban water users for development of new supplies. Also, some agricultural water users have historically been willing to accept a lower water supply reliability in return for less expensive water supplies. It can often be less expensive for self-supplied agricultural water users and users in small water agencies to idle land in drought years, rather than incur capital costs of new water supply development. This can be particularly true for regions already faced with production constraints, such as short growing seasons or lower quality lands -- areas where the dominant water use is often irrigated pasture. In areas such as the North Lahontan Region, for example, local agencies generally do not have plans for new programs or facilities to reduce agricultural water shortages in drought years. Table 10-5 shows forecasted future shortages by hydrologic region, to illustrate geographic variations in expected shortages

Table 10-5. Water Shortages by Hydrologic Region, With Implementation of Water Management Options (taf)

Region	1995		2020	
	Average	Drought	Average	Drought
North Coast	0	177	0	190
San Francisco Bay	0	349	0	71
Central Coast	214	282	34	170
South Coast	0	568	0	25
Sacramento River	111	867	0	780
San Joaquin River	239	788	768	1,369
Tulare Lake	870	1,862	409	1,031
North Lahontan	0	128	10	128
South Lahontan	89	92	159	180
Colorado River	69	95	0	0
Totals (rounded)	**1,590**	**5,210**	**1,380**	**3,490**

This table illustrates several concepts. For areas with forecasted shortages, there is a correlation between agencies having the ability to finance actions to meet those needs, and agencies having detailed plans to reduce shortages. Since the Bulletin's evaluation process is based on compilation of options that have, or are, being planned by local agencies, the tabulation reflects this correlation. Also, California's Urban Water Management Planning Act requires urban water suppliers with 3,000 or more connections, or that deliver over 3,000 af of water per year, to prepare urban water management plans that show how the agencies will meet their service area needs. Thus, many options have been generated from planning performed by urban agencies. An example is the South Coast Region, a region with high financial capability and extensive future planning by local water agencies. Even though this region has large forecasted average year and drought year shortages, there are options available to essentially eliminate the shortages.

Local agencies that expect to have significant future new demands generally do more planning than agencies where demands are expected to remain relatively level. Bulletin 160-98 forecasts a slight decline in irrigated acreage in 2020, and a large increase in California's population. Most agricultural water agencies are not faced with having to plan to meet new, larger future agricultural demands, although some agencies are examining ways to improve the

reliability of their existing supplies. Cost considerations limit the types of future options available to many agricultural users. Thus, the agricultural sector has tended to develop fewer options that could be included in future statewide water supply planning, as reflected in the relatively smaller shortage reductions in regions having high levels of agricultural water use.

Geography also plays a role in the feasibility of implementing different types of options, and not solely with respect to the availability of surface water and groundwater supply sources. Water users in the Central Valley, Bay Area, and Southern California having access to major regional conveyance facilities have greater opportunities to rely on transfers and exchanges, banking, and conjunctive use options than do water users isolated from the State's main water infrastructure.

Recommended Actions

The first recommendation is that water purveyors throughout the State implement water management options to reduce future shortages in their service areas. The second recommendation follows from the first -- that water purveyors statewide should continue to plan for additional options to address future water shortages. The magnitude of potential shortages, especially drought year shortages, demonstrates the urgency of taking action. The do-nothing alternative is not an alternative that will meet the needs of 47.5 million Californians in 2020.

There is not one magic bullet for meeting California's future water needs -- not new reservoirs, not new conveyance facilities, not more groundwater extraction, not more water conservation, not more water recycling. Each of these options has its place. The most frequently used methods of providing new water supplies have changed with the times, reflecting changing circumstances. Much of California's early water development was achieved by constructing reservoirs and diverting surface water. Advances in technology, in the form of deep well turbine pumps, subsequently allowed substantial groundwater development. More recent improvements in water treatment technology have made water recycling and desalting feasible options. Today, water purveyors are fortunate in having an array of water management options available to meet future water supply reliability needs.

All of the State's water purveyors have a role to play in meeting California's future water needs. The federal government operates California's largest water project, together with other

federally owned projects, and plays an important role in flood operations of some water supply facilities. At the State level, the Department operates California's second largest water project, administers dam safety and flood protection programs, and provides assistance to local agencies. SWRCB administers rights to surface water, balancing competing uses of California's waterbodies. Local water agencies provide about 70 percent of the State's developed water supplies, manage groundwater resources, and operate flood protection programs.

All three of California's water using sectors -- agricultural, environmental, and urban -- must work together to recognize each others' legitimate needs and to seek solutions to meeting the State's future water shortages. When the Bay-Delta Accord was signed three years ago, it was hailed as a truce in, if not an end to, one of the State's longstanding water wars. The Accord, and the efforts by California agencies to negotiate a resolution to interstate and intrastate Colorado River water issues, represent a new spirit of fostering cooperation and consensus rather than competition and conflict. Such an approach will be increasingly necessary, given the magnitude of the water shortages facing California. Mutual accommodation of each others' needs is especially important in drought years, when water purveyors face the greatest water supply challenges. With continued efforts to prepare for the future, California can have safe and reliable water supplies for urban areas, adequate long-term water supplies to maintain the State's agricultural economy, and restoration and protection of fish and wildlife habitat.

Appendix 2A. Institutional Framework for Allocating and Managing Water Resources in California

In California, water use and supplies are controlled and managed under an intricate system of federal and state laws. Common law principles, constitutional provisions, state and federal statutes, court decisions, and contracts or agreements all govern how water is allocated, developed, or used. All of these components, along with the responsible State, federal, and local agencies, compose the institutional framework for allocation and management of water resources in California.

This appendix presents an overview of California's institutional framework for managing water resources in California, highlighting some of the more recent changes. Summarized here are major constitutional requirements, statutes, court decisions, and agreements that form the groundwork for many water resource management and planning activities. Changes since the publication of Bulletin 160-93 are covered in Chapter 2.

Allocation and Management of California's Water Supplies

The following subsections condense basic water rights laws and doctrines governing allocation and use of California's water supplies.

California Constitution Article X, Section 2

The keystone to California's water law and policy, Article X, Section 2 of the California Constitution, requires that all uses of the State's water be both reasonable and beneficial. It places a significant limitation on water rights by prohibiting the waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water.

Riparian and Appropriative Rights

California operates under a dual system of water rights for surface water which recognizes both the doctrine of riparian rights and appropriative rights. Under the riparian doctrine, the owner of land has the right to divert, but not store, a portion of the natural flow of water flowing by his land for reasonable and beneficial use upon his land adjacent to the stream and within its watershed, subject to certain limitations. Generally, all riparian water right holders must reduce their water use in times of water shortages. Under the prior appropriation doctrine, a person has a right to divert, store, and use water regardless of whether the land on which it is

used is adjacent to a stream or within its watershed, provided that the water is used for reasonable and beneficial uses and is surplus to water from the same stream used by earlier appropriators. The rule of priority between appropriators is "first in time is first in right."

Water Rights Permits and Licenses

The Water Commission Act, which took effect in 1914 following a referendum, recognized the overriding interest of the people in the waters of the state, but provided that private rights to use the water may be acquired in the manner provided by law. The act established a system of state-issued permits and licenses to appropriate water. Amended over the years, it now appears in Division 2 (commencing with Section 1000) of the Water Code. These provisions place responsibility for administering appropriative water rights with the State Water Resources Control Board; however, the permit and license provisions do not apply to pre-1914 appropriative rights (those initiated before the act took effect in 1914). The act also provides procedures for adjudication of water rights, including court references to the State Water Resources Control Board and statutory adjudications of all rights to a stream system.

Groundwater Management

Generally, groundwater is available to any person who owns land overlying the groundwater basin. Groundwater management in California is accomplished either by a judicial adjudication of the respective rights of overlying users and exporters, or by local management of rights to extract and use groundwater as authorized by statute or agreement. Statutory management may be granted to a public agency that also manages surface water, or to a groundwater management agency created expressly for that purpose by a special district act.

In 1991, the Water Code was amended by AB 255 to allow local water agencies overlying critically overdrafted groundwater basins to develop groundwater management plans. Only a few local agencies adopted plans pursuant to that authorization. In 1992, the Legislature adopted new sections authorizing another form of groundwater management, also available to any local agency that provides water service, if the groundwater was not subject to management under other provisions of law or a court decree. Plans adopted pursuant to the 1992 statute (commonly called AB 3030 plans) may include control of salt water intrusion; identification and protection of well head and recharge areas; regulation of the migration of contaminated water; provisions for abandonment and destruction of wells; mitigation of overdraft; replenishment;

monitoring; facilitating conjunctive use; identification of well construction policies; and construction of cleanup, recharge, recycling, and extraction projects by the local agency. Table A2-1 lists agencies that had adopted AB 3030 plans as of January 1997. The table is based on surveys conducted by the Association of California Water Agencies and on plans submitted to the Department.

Table 2A-1. Agencies with AB 3030 Groundwater Management Plans

Alpaugh ID *	Joshua Basin WD	Santa Ynez River WCD
Alta ID	Kaweah Delta WCD	Sausalito ID
Angiola WD *	Kern Delta WD	Scotts Valley WD
Arcade WD	Kings River WD	Shafter-Wasco ID
Atwell Island WD*	Lakeside Irrigation WD	Solano ID
Banta-Carbona ID	Liberty WD	Soquel Creek ID
Biggs-West Gridley WD	Lower Tule River ID	South San Joaquin ID
Butte WD	Melga WD	South Sutter WD
Byron-Bethany ID	Modesto ID	Stockton East WD
Carpinteria Valley WD	Newhall CWD	Sutter Extension WD
Cawelo WD	North Kern WSD	Sweetwater Authority
Central WD	North San Joaquin WCD	Terra Bella ID
Citrus Heights WD	Oakdale ID	Tia Juana Valley CWD
City of Corcoran *	Pixley ID	Truckee-Donner PUD
Consolidated ID	Porterville ID	Tulare Lake Basin WSD*
Corcoran ID	Princeton-Codora-Glenn ID	Turlock ID
Del Puerto WD	Reclamation Dist. #108	United WCD
Eastern MWD	Reclamation Dist. #2035	West Stanislaus ID
Eastside WD	Rio Linda WD	Western Canal WD
El Camino ID	Riverdale ID	Westlands WD
Fresno ID	Rosamond CSD	Woodbridge ID
Glenn-Colusa ID	Sacramento Metro WA	
James ID	Santa Maria Valley WCD	

* Members of the Tulare Lake Bed Coordinated Groundwater Management Plan under a Joint Powers Agreement.

Public Trust Doctrine

In the 1980s, the Public Trust Doctrine was used by courts to limit traditional water rights. Under the Equal Footing Doctrine of the U.S. Constitution, each state has title to tidelands and the beds of navigable lakes and streams within its borders. The Public Trust Doctrine--

recognized in some form by most states--embodies the principle that the state holds title to such properties within the state in trust for the beneficial use of the public, and that public rights of access to and use of tidelands and navigable waters are inalienable. Traditional public trust rights include navigation, commerce, and fishing. California law has expanded the traditional public trust uses to include protection of fish and wildlife, preserving trust lands in their natural condition for scientific study and scenic enjoyment, and related open-space uses.

In 1983, the California Supreme Court extended the public trust doctrine's limitation on private rights to appropriative water rights. In *National Audubon Society v. Superior Court of Alpine County*, the court held that water right licenses held by the city of Los Angeles to divert water from streams tributary to Mono Lake remain subject to ongoing State supervision under the public trust doctrine. The court held that public trust uses must be considered and balanced when rights to divert water away from navigable water bodies are considered. The court also held that California's appropriative rights system and the public trust doctrine embody important precepts which ". . . make the law more responsive to the diverse needs and interests involved in planning and allocation of water resources." Consequently, in issuing or reconsidering any rights to appropriate and divert water, the State must balance public trust needs with the needs for other beneficial uses of water. In 1994, the SWRCB issued a final decision on Mono Lake (Decision 1631) in which it balanced the various uses in determining the appropriate terms and conditions of the water rights permit for the city of Los Angeles. The public trust doctrine will also be applied by the SWRCB in its current consideration of water rights in the Bay-Delta.

Since the 1983 National Audubon decision, the public trust doctrine has been involved in several other cases. In *United States v. State Water Resources Control Board* (commonly referred to as the Racanelli Decision and discussed below), the State Court of Appeal reiterated that the public trust doctrine is a significant limitation on water rights. The public trust doctrine was also a basis for the decision in *Environmental Defense Fund v. East Bay Municipal Utility District*. In this case, EDF claimed that EBMUD should not contract with USBR for water diverted from the American River upstream the Sacramento urban area in a manner that would harm instream uses including recreational, scenic, and fish and wildlife preservation purposes. The Superior Court upheld the validity of EBMUD's contract with USBR, but placed limitations on the timing and amounts of deliveries to EBMUD. As a result of these cases, the SWRCB now

routinely implements the public trust doctrine through regulations and through terms and conditions in water rights permits and licenses.

Federal Power Act

The Federal Power Act created a federal licensing system administered by the Federal Energy Regulatory Commission and requires that a license be obtained for nonfederal hydroelectric projects proposing to use navigable waters or federal lands. The act contains a clause modeled after a clause in the Reclamation Act of 1902, which disclaims any intent to affect state water rights law.

In a number of decisions dating back to the 1940s, the U.S. Supreme Court held that provisions of the Reclamation Act and the Federal Power Act preempted inconsistent provisions of law. Decisions under both acts found that these clauses were merely "saving clauses" which required the United States to follow minimal state procedural laws or to pay just compensation where vested nonfederal water rights are taken.

In *California v. United States* (1978), however, the U.S. Supreme Court overturned a number of earlier Supreme Court decisions which found that the Reclamation Act substantially preempts state water law. It held that the Reclamation Act clause requires the USBR to comply with conditions in state water rights permits unless those conditions conflict with "clear Congressional directives." In *California v. FERC* (1990), commonly referred to as the Rock Creek Decision, the U.S. Supreme Court rejected California's argument that the Federal Power Act clause required deference to state water law, as the Reclamation Act did. The Supreme Court distinguished between the two acts, finding that the Federal Power Act envisioned a broader and more active oversight role than did the Reclamation law. The *Federal District Court case of Sayles Hydro Association v. Maughan* (1993), reinforced this view by holding that federal law prevents any state regulation of federally licensed power projects other than determining proprietary water rights.

In 1994, the U.S. Supreme Court issued a decision referred to as the Elkhorn decision or Tacoma decision (*PUD No. 1 of Jefferson County and City of Tacoma v. Washington Department of Ecology*). The court held that a state minimum instream flow requirement is a permissible condition of a Clean Water Act Section 401 certification, in response to a proposal to construct a hydroelectric project on the Dosewallips River. Pursuant to Section 401 of the Clean

Water Act, the project proponents were required to obtain state certification for the hydroelectric project. The State of Washington set an instream flow requirement in its certification process to protect the river's designated use as fish habitat. Section 303 of the Clean Water Act requires states to establish water quality standards for intrastate waters, with the standards to include both numeric water quality criteria and designated uses.

Area of Origin Statute. During the years when California's two largest water projects, the Central Valley Project and State Water Project, were being planned and developed, area of origin legislation was enacted to protect local Northern California supplies from being depleted as a result of the projects. County of origin statutes reserve water supplies for counties in which the water originates when, in the judgment of the SWRCB, an application for the assignment or release from priority of state water right filings will deprive the county of water necessary for its present and future development. Watershed protection statutes are provisions which require that the construction and operation of elements of the CVP and the SWP not deprive the watershed, or area where water originates, or immediately adjacent areas which can be conveniently supplied with water of the prior right to water reasonably required to supply the present or future beneficial needs of the watershed area or any of its inhabitants or property owners.

The Delta Protection Act, enacted in 1959 (not to be confused with the Delta Protection Act of 1992, which relates to land use), declares that the maintenance of an adequate water supply in the Delta--to maintain and expand agriculture, industry, urban, and recreational development in the Delta area and provide a common source of fresh water for export to areas of water deficiency--is necessary for the peace, health, safety, and welfare of the people of the state, and is subject to the County of Origin and Watershed Protection laws. The act requires theSWP and the CVP to provide an adequate water supply for water users in the Delta through salinity control or through substitute supplies in lieu of salinity control.

In 1984, additional area of origin protections were enacted covering the Sacramento, Mokelumne, Calaveras, and San Joaquin rivers; the combined Truckee, Carson, and Walker rivers; and Mono Lake. The protections prohibit the export of groundwater from the combined Sacramento River and Sacramento-San Joaquin Delta basins, unless the export is in compliance with local groundwater plans.

Environmental Regulatory Statutes and Programs

Endangered Species Act

Under the federal ESA, an endangered species is one that is in danger of extinction in all or a significant part of its range, and a threatened species is one that is likely to become endangered in the near future. The ESA is designed to preserve endangered and threatened species by protecting individuals of the species and their habitat and by implementing measures that promote their recovery. The ESA sets forth a procedure for listing species as threatened or endangered. Final listing decisions are made by the United States Fish and Wildlife Service or the National Marine Fisheries Service.

Once a species is listed, Section 7 of the act requires that federal agencies, in consultation with the USFWS or NMFS, ensure that their actions do not jeopardize the continued existence of the species or habitat critical for the survival of that species. The federal wildlife agencies are required to provide an opinion as to whether the federal action would jeopardize the species. The opinion must include reasonable and prudent alternatives to the action that would avoid jeopardizing the species' existence. Federal actions subject to Section 7 include issuance of federal permits such as the dredge and fill permit required under Section 404 of the federal Clean Water Act, which requires that the project proponent demonstrate that there is no feasible alternative consistent with the project goals that would not affect listed species. Mitigation of the proposed project is not considered until this hurdle is passed.

State agencies and private parties also are subject to the ESA. Section 9 of the ESA prohibits the "take" of endangered species and threatened species for which protective regulations have been adopted. Take has been broadly defined to include actions that harm or harass listed species or that cause a significant loss of their habitat. State agencies and private parties are generally required to obtain a permit from the USFWS or NMFS under Section 10(a) of the ESA before carrying out activities that may incidentally result in taking listed species. The permit normally contains conditions to avoid taking listed species and to compensate for habitat adversely impacted by the activities.

California Endangered Species Act

The California Endangered Species Act is similar to the federal ESA and must be complied with in addition to the federal ESA. Listing decisions are made by the California Fish

and Game Commission.

All State lead agencies are required to consult with the Department of Fish and Game about projects that impact State listed species. DFG is required to render an opinion as to whether the proposed project jeopardizes a listed species and to offer alternatives to avoid jeopardy. State agencies must adopt reasonable alternatives unless there are overriding social or economic conditions that make such alternatives infeasible. For projects causing incidental take, DFG is required to specify reasonable and prudent measures to minimize take. Any take that result from activities that are carried out in compliance with these measures is not prohibited.

Many California species are both federally listed and State listed. CESA directs DFG to coordinate with the USFWS and NMFS in the consultation process so that consistent and compatible opinions or findings can be adopted by both federal and State agencies.

Natural Community Conservation Planning

Adopted in 1991, California's Natural Community Conservation Planning Act establishes a program to identify the habitat needs of species before they become listed as threatened or endangered, and to develop appropriate voluntary conservation methods compatible with development and growth. This program is designed to preserve habitat for the variety of species that are dependent upon each other. Participants in the program develop plans to protect certain habitat and will ultimately enter into agreements with DFG to ensure that the plans will be carried out. Plans must be created so that they are consistent with endangered species laws.

Dredge and Fill Permits

Section 404 of the federal Clean Water Act regulates the discharge of dredged and fill materials into waters of the United States, including wetlands. The term "discharge of dredged and fill material" has been defined broadly to include the construction of any structure involving rock, soil, or other construction material. No discharge may occur unless a permit is obtained from the USACE. Generally, the project proponent must agree to mitigate or have plans to mitigate environmental impacts caused by the project before a permit is issued. The EPA has the authority to veto permits issued by the Corps for projects that have unacceptable adverse effects on municipal water supplies, fisheries, wildlife, or recreational areas.

Section 404 allows the issuance of a general permit on a State, regional, or nationwide basis for certain categories of activities that will cause only minimal environmental effects. Such

activities are permitted without the need of an individual permit application. Installation of a stream gaging station along a river levee is one example of an activity which falls within a nationwide permit.

The USACE also administers a permitting program under Section 10 of the 1899 Rivers and Harbors Act. Section 10 generally requires a permit for obstructions to navigable water. The scope of the permit under Section 10 is narrower than under Section 404 since the term "navigable waters" is more limited than "waters of the United States."

The majority of water development projects must comply with Section 404, Section 10, or both.

Public Interest Terms and Conditions

The Water Code authorizes the SWRCB to impose public interest terms and conditions to conserve the public interest, specifically the consideration of instream beneficial uses, when it issues permits to appropriate water. It also considers environmental impacts of approving water transfers under its jurisdiction. Frequently, it reserves jurisdiction to consider new instream uses and to modify permits accordingly.

Releases of Water for Fish

Fish and Game Code Section 5937 provides protection to fisheries by requiring that the owner of any dam allow sufficient water at all times to pass through the dam to keep in good condition any fisheries that may be planted or exist below the dam. In *California Trout, Inc. v. the State Water Resources Control Board* (1989), the court determined that Fish and Game Code sections 5937 and 5946 require the SWRCB to modify the permits and licenses issued to the city of Los Angeles to appropriate water from the streams feeding Mono Lake to ensure sufficient water flows for downstream fisheries. The SWRCB reconsidered Los Angeles's permits and licenses in light of Fish and Game Code section 5937 and the public trust doctrine. In 1994, the SWRCB adopted D-1631, which requires Los Angeles to allow sufficient flows from the streams feeding Mono Lake to reach the lake to cause it to rise to the level of 6,391 feet in approximately twenty years.

Streambed Alteration Agreements

Fish and Game Code Sections 1601 and 1603 require that any governmental entity or private party altering a river, stream, lake bed, bottom or channel enter into an agreement with

the DFG. When the project may substantially impact an existing fish or wildlife resource, DFG may require that the agreement include provisions designed to protect riparian habitat, fisheries, and wildlife. New water development projects and ongoing maintenance activities are often subject to these sections.

Migratory Bird Treaty Act

This act implements various treaties for the protection of migratory birds and prohibits the "taking" (broadly defined) of birds protected by those treaties without a permit. The Secretary of the Interior determines conditions under which a taking may occur, and criminal penalties are provided for unlawfully taking or transporting protected birds. Liability imposed by this act was one of several factors leading to the decision to close the San Luis Drain and Kesterson Reservoir.

Environmental Review and Mitigation

Another set of environmental statutes compels governmental agencies and private individuals to document and consider the environmental consequences of their actions. They define the procedures through which governmental agencies consider environmental factors in their decision-making process.

National Environmental Policy Act

NEPA directs federal agencies to prepare an environmental impact statement for all major federal actions which may have a significant effect on the human environment. It states that it is the goal of the federal government to use all practicable means, consistent with other considerations of national policy, to protect and enhance the quality of the environment. It is a procedural law requiring all federal agencies to consider the environmental impacts of their proposed actions during the planning and decision-making processes.

California Environmental Quality Act

CEQA, modeled after NEPA, requires California public agency decision-makers to document and consider the environmental impacts of their actions. It requires an agency to identify ways to avoid or reduce environmental damage, and to implement those measures where feasible. CEQA applies to all levels of California government, including the State, counties, cities, and local districts.

CEQA requires that a public agency carrying out a project with significant environmental

effects prepare an environmental impact report. An EIR contains a description of the project; a discussion of the project's environmental impacts, mitigation measures, and alternatives; public comments; and the agency's responses to the comments. In other instances, a notice of exemption from the application of CEQA may also be appropriate.

NEPA does not generally require federal agencies to adopt mitigation measures or alternatives provided in the EIS. CEQA imposes substantive duties on all California governmental agencies that approve projects with significant environmental impacts to adopt feasible alternatives or mitigation measures that substantially lessen these impacts, unless there are overriding reasons. When a project is subject to both CEQA and NEPA, both laws encourage the agencies to cooperate in planning the project and to prepare joint environmental documents.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act expresses Congressional policy to protect the quality of the aquatic environment as it affects the conservation, improvement, and enjoyment of fish and wildlife resources. Under this act, any federal agency that proposes to control or modify any body of water, or to issue a permit allowing control or modification of a body of water, must first consult with the USFWS and state Fish and Game officials. This requires coordination early in the project planning and environmental review processes.

Protection of Wild and Natural Areas

Water use and management are also limited by several statutes designed to set aside resources or areas to preserve their natural conditions. These statutes preclude many activities, including most water development projects, within the areas set aside.

Federal Wild and Scenic Rivers System

In 1968, Congress passed the National Wild and Scenic Rivers Act to preserve, in their free-flowing condition, rivers which possess "outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values." The act also states: " . . . that the established national policy of dam and other construction at appropriate sections of rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes."

The act prohibits federal agencies from constructing, authorizing, or funding the construction of water resources projects having a direct and adverse effect on the values for which a river was designated. This restriction also applies to rivers designated for potential addition to the National Wild and Scenic Rivers System. Included in the system are most rivers protected under California's State Wild and Scenic Rivers Act; these rivers were included in the national system upon California's petition on January 19, 1981. The West Walker and East Fork Carson rivers are not included in the federal system.

California Wild and Scenic Rivers System

In 1972, the California legislature passed the State Wild and Scenic Rivers Act, declaring that specified rivers possess extraordinary scenic, recreational, fishery, or wildlife values that should be preserved in a free-flowing state for the benefit of the people of California. It declared that such use of the rivers would be the highest and most beneficial use within the meaning of Article X, Section 2 of the California Constitution. The act prohibits construction of any dam, reservoir, diversion, or other water impoundment on a designated river. Diversions needed to supply domestic water to residents of counties through which the river flows may be authorized, if the Secretary for Resources determines that the diversion will not adversely affect the river's free-flowing character.

The major difference between the national and state acts is that if a river is designated wild and scenic under the State act, the Federal Energy Regulatory Commission can still issue a license to build a dam on that river, thus overriding the state system. (See Federal Power Act discussion above.) This difference explains why national wild and scenic designation is often sought.

National Wilderness Act

The Wilderness Act sets up a system to protect federal land designated by Congress as a "wilderness area" and preserve it in its natural condition. Wilderness is defined as undeveloped federal land retaining its primeval character and influence without permanent improvements or human habitation. Commercial enterprise, permanent roads, motor vehicles, aircraft landings, motorized equipment, or construction of structures or installations (such as dams, diversions, conveyance facilities, and gaging stations) are prohibited within designated wilderness areas.

Water Quality Protection

Water quality is an important aspect of water resource management. The SWRCB plays a central role in determining both water rights and regulating water quality. The Department of Health Services has regulatory oversight over drinking water quality, a program administered in coordination with county environmental health agencies. Discussed below are key state and federal laws governing water quality.

Porter-Cologne Water Quality Control Act

This act is California's comprehensive water quality control law and is a complete regulatory program designed to protect water quality and beneficial uses of the State's water. The act requires the adoption of water quality control plans by the State's nine regional water quality control boards for areas within their regions. These plans are subject to the approval of the SWRCB, and ultimately the federal EPA. The plans are to be reviewed and updated.

The primary method of implementing the plans is to require each discharger of waste that could impact the waters of the state to meet formal waste discharge requirements. Anyone discharging waste or proposing to discharge waste into the state's water must file a "report of waste discharge" with the regional water quality control board within whose jurisdiction the discharge lies. Dischargers are subject to a wide variety of administrative, civil, and criminal actions for failing to file a report. After the report is filed, the regional board may issue waste discharge requirements that set conditions on the discharge. The waste discharge requirements must be consistent with the water quality control plan for the body of water and protect the beneficial uses of the receiving waters. The regional boards also implement Section 402 of the federal Clean Water Act, which allows the state to issue a single discharge permit for the purposes of both state and federal law.

Clean Water Act -- National Pollutant Discharge Elimination System

Section 402 of the Clean Water Act established a permit system known as the National Pollutant Discharge Elimination System to regulate point sources of discharges in navigable waters of the United States. The EPA was given the authority to implement the NPDES, although the act also authorizes states to implement the act in lieu of the EPA, provided the state has sufficient authority.

In 1972, the California Legislature passed a law amending the Porter-Cologne Act which gave California the authority and ability to operate the NPDES permits program. Before a permit may be issued, Section 401 of the Clean Water Act requires that the Regional Water Quality Control Board certify that the discharge will comply with applicable water quality standards. After making the certification, the regional board may issue the permit, satisfying both state and federal law. In 1987, Section 402 was amended to require the regulation of storm water runoff under the NPDES.

Safe Drinking Water Act

The SDWA, enacted in 1974 and significantly amended in 1986 and 1996, directed the EPA to set national standards for drinking water quality. It required the EPA to set maximum contaminant levels for a wide variety of constituents. Local water suppliers are required to monitor their water supplies to assure that regulatory standards are not exceeded.

The 1986 amendments set a timetable for the EPA to establish standards for specific contaminants and increased the range of contaminants local water suppliers were required to monitor to include contaminants that did not yet have an MCL established. The amendments included a wellhead protection program, a grant program for designating sole-source aquifers for special protection, and grant programs and technical and financial assistance to small systems and states.

The 1996 amendments added a provision requiring states to create their own state revolving fund in order to be eligible to receive federal matching funds for loans and grants to public water systems. More details of the 1996 amendments are described in Chapter 2.

California Safe Drinking Water Act

In 1976, California enacted its own Safe Drinking Water Act, requiring the Department of Health Services to administer laws relating to drinking water regulation including: setting and enforcing both federal and state drinking water standards, administering water quality testing programs, and administering permits for public water system operations. The federal Safe Drinking Water Act allows the state to enforce its own standards in lieu of the federal standards so long as they are at least as protective as the federal standards. Significant amendments to the state's act in 1989 incorporated the new federal safe drinking water act requirements into California law, gave DHS discretion to set more stringent MCLs, and recommended public

health levels for contaminants. DHS was authorized to consider the technical and economic feasibility of reducing contaminants in setting MCLs. The standards established by DHS are found in the California Code of Regulations, Title 22.

Historic Background -- Bay-Delta Regulatory Actions

The SWRCB issued the first water rights permits to the USBR for operation of the CVP in 1958, and to DWR for operation of the SWP in 1967. In these and all succeeding permits issued for the CVP and SWP, the SWRCB reserved jurisdiction to reformulate or revise terms and conditions relative to salinity control, effect on vested rights, and fish and wildlife protection in the Sacramento-San Joaquin Delta. The Board has a dual role of issuing both water rights permits and regulating water quality.

Decision 1485

In 1976, the Board initiated proceedings leading to the adoption of Water Right Decision 1485 in 1978. Decision 1485 set forth conditions--including water quality standards, export limitations, and minimum flow rates--for SWP and CVP operations in the Delta and superseded all previous water rights decisions for the SWP and CVP operations in the Delta. Among beneficial uses to be protected by the decision were: (1) municipal and industrial water supply, (2) agriculture, and (3) fish and wildlife.

In formulating Decision 1485, the SWRCB asserted that Delta water quality should be at least as good as it would have been if the SWP and CVP had not been constructed. In other words, both the SWP and the CVP were to be operated to meet "without project" conditions. Decision 1485 standards included different levels of protection to reflect variations in hydrologic conditions during different types of water years.

To help implement these water quality standards, Decision 1485 mandated an extensive monitoring program. It also called for special studies to provide critical data about major concerns in the Delta and Suisun Marsh for which information was insufficient. Decision 1485 included water quality standards for Suisun Marsh, as well as for the Delta, requiring DWR and the USBR to develop a plan for the marsh that would ensure meeting long-term standards.

Recognizing that the complexities of project operations and water quality conditions would change over time, the SWRCB also specified that the Delta water right hearings would be reopened within ten years of the date of adoption of Decision 1485, depending upon changing

conditions in the Bay-Delta region and the availability of new evidence on beneficial uses of water.

Racanelli Decision

Lawsuits by various interests challenged Decision 1485 and the decision was overturned by the trial court in 1984. Unlike its predecessor, D-1379, whose standards had been judicially stayed, D-1485 remained in effect. In 1986, the appellate court in the Racanelli Decision (named after Judge Racanelli who wrote the opinion) broadly interpreted the SWRCB's authority and obligation to establish water quality objectives, and its authority to set water rights permit terms and conditions that provide reasonable protection of beneficial uses of Delta water of San Francisco Bay.

The court stated that SWRCB needed to separate its water quality planning and water rights functions. SWRCB needs to maintain a "global perspective" in identifying beneficial uses to be protected (not limited to water rights) and in allocating responsibility for implementing water quality objectives (not just to the SWP and CVP, nor only through the SWRCB's own water rights processes). The court recognized the SWRCB's authority to look to all water rights holders to implement water quality standards and advised the Board to consider the effects of all Delta and upstream water users in setting and implementing water quality standards in the Delta, as well as those of the SWP and the CVP.

SWRCB Bay-Delta Proceedings

Hearings to adopt a water quality control plan and water rights decision for the Bay-Delta estuary began in July 1987. Their purpose was to develop a San Francisco Bay-Sacramento-San Joaquin Delta water quality control plan and to consider public interest issues related to Delta water rights, including implementation of water quality objectives. During the first phase of the proceedings, testimony was heard on issues pertaining to the reasonable and beneficial uses of the estuary's water. The second phase of the Bay-Delta hearings was to come up with a water quality control plan. SWRCB adopted a final plan in May 1991. The federal EPA rejected this plan in September 1991, setting the stage for preparation of federal water quality standards for the Bay-Delta.

With the adoption of the Water Quality Control Plan, the SWRCB began the EIR scoping phase and held several workshops during 1991 to receive testimony regarding planning activities,

facilities development, negotiated settlements, and flow objectives.

Concurrently, under the broad authority of the Endangered Species Act, the federal regulatory process was proceeding toward development of Delta standards and upstream measures applicable to the CVP and SWP for the protection of the threatened winter-run chinook salmon. In February 1993, the NMFS issued a long-term biological opinion governing operations of the CVP and SWP with Delta environmental regulations that, in certain months, were more restrictive than SWRCB's proposed measures. In March 1993, the USFWS listed the Delta smelt as a threatened species and shortly thereafter indicated that further restrictions of CVP and SWP operations would be required. In December 1993, EPA announced its proposed standards for the estuary in place of the SWRCB water quality standards EPA had rejected in 1991. In addition, USFWS proposed to list the Sacramento splittail as a threatened species, and NMFS announced its decision to change the status of winter-run salmon from threatened to endangered.

The impending regulatory gridlock lead to the negotiation and signing of the June 1994 Framework Agreement for the Bay-Delta Estuary. The Framework Agreement and subsequent Bay-Delta activities are described in Chapter 2.

Fish Protection Agreements. To mitigate fish losses at Delta export facilities, both the SWP and the CVP have entered into agreements with DFG. As part of the environmental review process for installing four additional pumps at DWR's Banks Pumping Plant in the Delta in 1992, DFG and DWR negotiated an agreement to preserve fish potentially affected by the operation of the pumps. This agreement, signed by the two departments in 1986, identifies the steps needed to offset adverse impacts of the Banks Pumping Plant on fisheries. It sets up a procedure to calculate direct fishery losses annually and requires DWR to pay for mitigation projects that would offset the losses. Losses of striped bass, chinook salmon, and steelhead are to be mitigated first. Mitigation of other species is to follow as impacts are identified and appropriate mitigation measures found. In recognition of the fact that direct losses today would probably be greater if fish populations had not been depleted by past operations, DWR also provided a $15 million capital outlay for a program to increase the probability of quickly demonstrated results. In 1996, DWR and DFG agreed to extend the period for expending the remainder of the $15 million to the year 2001.

Following negotiation of the agreement for Banks Pumping Plant, DFG negotiated a similar agreement with USBR for its Tracy Pumping Plant.

Surface Water Management

The following sections are brief descriptions of major statutes affecting surface water management in California.

CVPIA

The Central Valley Project Improvement Act (Title 34 of PL 102-575) made significant changes to the CVP's legislative authorization, amending the project's purposes to place fish and wildlife mitigation and restoration on a par with water supply, and to place fish and wildlife enhancement on a par with power generation. Major provisions of the act are summarized below.

The act prohibits execution of new water supply contracts for purposes other than fish and wildlife (with a few limited exceptions) until all environmental restoration actions specified in the act have been completed. Existing long-term water supply contracts are to be renewed for a 25-year term, with the possibility of subsequent 25-year renewals thereafter. Only interim contract renewals are allowed until the programmatic EIS required by the act is completed. Renewed contracts are to incorporate CVPIA's new requirements, such as Restoration Fund payments.

The act allows transfers of project water to users outside of the CVP service area, under numerous specified conditions. The conditions include a right of first refusal to a proposed transfer by existing CVP water users (under the same terms and conditions specified in the proposed transfer), and a requirement that proposed transfers of more than 20 percent of a contracting agency's project water supply be subject to review and approval by the contracting agency.

The act requires DOI to develop water conservation criteria, and to review conservation plans submitted by contracting agencies pursuant to Reclamation Reform Act requirements for conformance to the CVPIA criteria. Tiered pricing is to be included in CVP water supply contracts when they are renewed. Project water supply and repayment contractors' surface water delivery systems are to be equipped with water measurement devices.

The act directs DOI to develop a program, by October 1995, to make all reasonable efforts to double, by 2002, natural production (based on 1967-1991 fishery population levels) of

specified anadromous fish in the Central Valley, and to implement that program. [A portion of the San Joaquin River is exempted from this provision.] The act dedicates 800 TAF of CVP yield to fish and wildlife purposes, and authorizes DOI to acquire supplemental water for meeting the fish doubling goal. The act further requires an annual Trinity River instream flow of at least 340 TAF through 1996, with subsequent instream flow requirements to be determined by a USFWS instream flow study.

The act requires DOI to provide, from CVP supplies, firm water supplies (i.e., deliver water corresponding to existing non-firm supplies such as agricultural drainage) to specified federal, state, and private wildlife refuges in the Sacramento and San Joaquin valleys. DOI is to acquire, from willing sellers, an additional increment of water supply for the wildlife areas, corresponding to their full habitat development needs. All of the supplemental water needs are to be met by 2002.

The act requires DOI to implement numerous specified environmental restoration actions, such as constructing a temperature control device at Shasta Dam, remedying fish passage problems at Red Bluff Diversion Dam, replenishing spawning gravel, and assisting in screening non-federal diversions. Costs of some of these restoration actions are allocated in part to the State of California. DOI is required to enter into a cost-sharing agreement with California for the environmental restoration actions whose costs are allocated in part to California.

The act requires DOI to prepare specified reports and studies, to implement a Central Valley fish and wildlife monitoring program, and to develop ecosystem and water operations models. Examples of reports to be prepared include a least-cost plan to replace the 800 TAF of project yield dedicated to environmental purposes, and an evaluation of water supply and development requirements for 120,000 acres of wetlands identified in a Central Valley Habitat Joint Venture report. DOI is also directed to prepare, by October 1995, a programmatic EIS analyzing impacts of CVPIA implementation.

The act authorizes DOI to carry out a land retirement program, and specifies categories of land that may be acquired. San Joaquin Valley drainage-impaired lands are among the authorized categories.

The act establishes a CVPIA Restoration Fund within the federal treasury, and directs DOI to collect mitigation and restoration payments from project water and power users. DOI is

authorized to use appropriations from the fund to carry out the environmental restoration measures required by the act. Payments are capped at $6 per acre-foot for agricultural water contractors and $12 per acre-foot for municipal and industrial water contractors (all amounts are in 1992 dollars). (An additional restoration payment is assessed against contractors in the Friant Division, in lieu of requiring Friant Dam releases for instream flows in the San Joaquin River between Gravelly Ford and the Mendota Pool.)

Regional and Local Water Projects

In general, there are two methods in the State of California for forming special districts which are concerned directly or incidentally with the development, control or distribution of water: (1) by enactment of a general act under which the districts may be formed in accordance with a procedure set forth in the act, and (2) by a special act creating the district and prescribing its powers. There are more than 40 different statutes under which local agencies may be organized and have, among their powers, the authority to distribute water. In addition, there are a number of special act districts, such as the Metropolitan Water District of Southern California. DWR Bulletin 155-94, *General Comparison of Water District Acts* (March 1994), presents a comparison of various water district acts in California.

In addition to public agencies, there are other entities that may provide water supply. Mutual water companies, for example, are private corporations that perform water supply and distribution functions similar to public water districts. Investor-owned utilities may also be involved in water supply activities, sometimes as an adjunct of hydroelectric power development.

Water Use Efficiency

Article X, Section 2 of the California Constitution prohibits the waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water. It also declares that the conservation and use of water "shall be exercised with a view to the reasonable and beneficial use thereof in the public interest and for the public welfare." Although provisions and requirements of the Constitution are self executing, the Constitution states that the Legislature may enact statutes to advance its policy. Water Code Section 275 directs DWR and the SWRCB to "take all appropriate proceedings or actions before executive, legislative, or judicial agencies to prevent waste or unreasonable use of water." SWRCB's Water Right Decision 1600, directing the Imperial Irrigation District to adopt a water conservation plan, is an example of an action

brought under Article X, Section 2. The board's authority to order preparation of such a plan was upheld in 1990 by the courts in *Imperial Irrigation District v. State Water Resources Control Board.*

Urban Water Management Planning Act

Since 1983, this act has required urban water suppliers that serve more than 3,000 customers or more than 3,000 acre-feet per year to prepare and adopt urban water conservation plans. The act authorizes the supplier to implement the water conservation program. The plans must contain several specified elements, including: estimates of water use, identification of existing conservation measures, identification of alternative conservation measures, a schedule of implementation of actions proposed by the plan, and identification of the frequency and magnitude of water shortages. In 1991, the act was amended in response to the drought to require water suppliers to estimate water supplies available at the end of one, two, and three years, and to develop contingency plans for severe shortages. The act also requires water suppliers to review and update their plans at least once every five years.

Water Conservation in Landscaping Act

The Water Conservation in Landscaping Act required the Department, with the assistance of an advisory task force, to adopt a model water-efficient landscape ordinance. The model ordinance was adopted in August 1992, and has been codified in Title 23 of the California Code of Regulations. It establishes methods of conserving water through water budgeting plans, plant use, efficient irrigation, auditing, and other methods.

Cities and counties were required to review the model ordinance and adopt a water-efficient landscape ordinance by January 1, 1993, if they had not done so already. Alternatively, cities and counties could make a finding that such an ordinance is unnecessary due to climatic, geological, or topographic conditions, or water availability. If a city or county failed to adopt a water efficient landscape ordinance or make findings by January 31, 1993, the model ordinance became effective in that jurisdiction.

Agricultural Water Management Planning Act

Under this act, agricultural water suppliers supplying more than 50,000 af of water annually were required to submit a report to the Department indicating whether a significant opportunity exists to conserve water or reduce the quantity of highly saline or toxic drainage

water through improved irrigation water management. The act provided that agricultural water suppliers, who indicated that they had an opportunity to conserve water or reduce the quantity of highly saline or toxic water, should to prepare a water management plan and submit it to the Department. The Department was required to review the plans and submit a report to the Legislature by January 1993.

Agricultural Water Suppliers Efficient Management Practices Act

The Agricultural Water Suppliers Efficient Management Practices Act, adopted in 1990, required that the Department establish an advisory task force to review efficient agricultural water management practices. Under the act, the Department is required to offer assistance to agricultural water suppliers seeking to improve the efficiency of their water management practices. The committee developed a Memorandum of Understanding to implement the practices, which is currently being circulated for signature.

Agricultural Water Conservation and Management Act of 1992

This act gives any public agency that supplies water for agricultural use authority to institute water conservation or efficient management programs. The programs can include irrigation management services, providing information about crop water use, providing irrigation consulting services, improving the supplier's delivery system, providing technical and financial assistance to farmers, encouraging conservation through pricing of water, and monitoring.

Water Recycling Act of 1991

This act describes the environmental benefits and public safety of using recycled water as a reliable and cost-effective method of helping to meet California's water supply needs. It sets a statewide goal to recycle 700,000 af per year by the year 2000 and 1 maf by the year 2010.

Appendix 4A. Urban and Agricultural Water Pricing

This appendix is provided as background material to respond to interest expressed by Bulletin 160-98 reviewers in water pricing information. Water prices in California vary widely, as discussed below. The more than 2,800 local agencies in California that provide water service establish their prices based on factors specific to their individual service areas, and those prices are generally reviewed by agencies' elected or appointed boards of directors, or by the California Public Utility Commission.

Water Retail Pricing

Many factors influence the water prices charged by water agencies. Some of the major factors include water acquisition and delivery costs, water supply availability, pricing policies, climatic conditions and the characteristics of the service area.

There are many kinds of water agencies in the state, as shown in Table 4A-1. For public water agencies, the types of charges levied depends upon the legislation under which they were created. Descriptions of the general powers of the public agencies shown in the table can be found in DWR's Bulletin 155-94, *General Comparison of Water District Acts*, published in March 1994. Investor-owned utilities water rates are set by the California Public Utilities Commission. Mutual water companies, which are privately owned, set their own rates for their members.

Acquisition and Delivery Costs

Foremost among acquisition costs are those associated with obtaining water from a source--which may vary greatly from one source to another. Many water agencies have not developed their own water sources. Instead, they purchase water wholesale from other suppliers. Other significant costs include transportation and local delivery charges and water treatment costs. Supplies delivered for urban use require treatment, which is becoming an increasingly greater component of total cost as more stringent drinking water quality regulations are put into place. Compliance with recent surface water filtration and information collection requirements of the Safe Drinking Water Act, for example, is a substantial cost item for many water agencies.

Table 4A-1. Types of Local Water Agencies in California

Type of Agency	*Ownership*	*Number*
County Service Area	Public	880
Mutual Water Company	Private	801
Community Services District	Public	309
Investor-Owned Water Utility	Private	195
County Water District	Public	178
Water District	Public	157
Irrigation District	Public	97
Public Utility District	Public	52
Flood Control and Water Conservation District	Public	41
County Water Works District	Public	40
Municipal Water District	Public	40
Water Agency or Water Authority	Public	31
Water Conservation District	Public	13
Water Storage District	Public	8
Municipal Utility District	Public	5
Water Replenishment District	Public	2
Metropolitan Water District	Public	1
Total		**2,850**

Source: Department of Health Services and State Controller's Office data, 1994-96.

Some water agencies use water rates to fully recover the costs of acquiring, treating, and delivering supplies; others use a combination of water rates and local property taxes. Another important policy concerns whether a water agency sets its rates to reflect costs that will be incurred over the short-term (less than 5 years in the future) or over the long-term (greater than 5 years). This is especially significant if a water agency's system is currently operating at (or above) capacity, and major system improvements or expansion are needed. If this is the case, the water agency may need to adjust its rates to reflect the higher marginal costs of future system expansion.

Water Availability

During droughts, the rates water agencies charge may vary depending on supply reliability and availability. For example, during the 1987-92 drought, many water agencies adopted higher rates to fund programs to encourage water conservation, and several implemented drought penalty rates designed to reduce water use drastically. These policies reduced water use; however, an unwanted consequence of reduced water use was reduced revenues to the water agencies, which still had to pay their system's fixed costs plus the costs of expanded conservation programs. To remain solvent, many water agencies had to increase rates several times during the

drought.

Characteristics of Service Area

A water agency's costs also will be affected by the mix of residential, commercial, industrial, governmental and agricultural users within the service area, because the cost of service to these users is likely to be different. If a water agency serves a heavily populated area with many connections per square mile, the average fixed costs per customer will tend to be less. Conversely, if the purveyor serves a sparsely populated area, the average fixed costs of serving each customer normally will be high. Changes in elevation within a service are can also affect delivery costs, because of associated pumping costs.

Rate Structure

Water rates are the primary source of income for most water agencies. Although these rates can be structured numerous ways, typically they include some form of fixed charges, consumption-based charges, or a combination of both.

Fixed charges typically recover some or all of the water agency's fixed costs, such as debt service incurred from project construction and administrative costs. These costs are incurred irrespective of the amount of water used. Fixed rates are typically used by water agencies that do not meter consumption. For metered urban water agencies, examples of fixed charges include billing and administrative charges (service charges); lifeline charges for a minimum level of service; "readiness to serve" charges; and fire protection charges. Agricultural fixed charges (often called water availability or standby charges) can be levied on a per acre or connection basis. Fixed charges which are levied on a per acre or parcel basis will likely be affected by the recent passage of Proposition 218, which is discussed in more detail in Chapters 2 and 6.

Consumption-based charges typically are set on a per unit volume basis so the total charge varies with the user's consumption. These charges typically recover the variable costs of water deliveries (i.e., costs that vary with the amount of water delivery, such as water purchases, treatment, and pumping costs), although some fixed costs also may be recovered. Consumption-based charges are often used to help manage or allocate demand during periods of limited water supply capacity or availability. As with fixed rates, there are several forms of consumption-based rates. One form is the constant charge, which is the same unit price for all units of water that are consumed; another consumption-based rate are block rates, which either

decrease (declining block) or increase (increasing block) with water consumption. A declining block rate sets a reduced price per unit for increased usage. Increasing block rates set increasing prices per unit for increased usage, and as a result, are more likely to encourage water conservation. Constant and increasing block rates are the predominant urban rate structures currently used in the State. However, some forms of declining rates may still be used in urban areas, especially in communities wishing to use lower water rates as an incentive for industry to locate in their area. Some agencies use declining block rates and other incentives to encourage use of recycled water in lieu of potable supplies. Agricultural water agencies levy consumption-based charges based upon either the actual amount of water delivered or on the number of acres irrigated by the farmers with supplies from the agency (these charges may vary depending upon the crop type).

Assessments

The above charges typically account for most of a water agency's total revenues. However, revenues also can be obtained from assessments, or taxes, levied upon lands in accord with benefits received from an agency's actions or projects. Assessments recover a portion of an agency's fixed costs, and can be levied either on those lands which directly benefit from water deliveries (for example, land receiving irrigation water) or on lands which indirectly benefit from water deliveries (adjoining lands which may benefit from groundwater recharge resulting from the project).

Cities may charge for sewer and sewage treatment based on water use. For some of these cities, the sewer charges are included in the monthly service charges and commodity rates paid by the water users. Other cities charge for sewers based on water use, but keep the sewer charges separate from the water charges.

Urban Retail Water Costs

Since 1990 there have been a few statewide surveys of urban retail water costs in California. One, conducted by the Department in 1991, included about 70 communities throughout the State. The results of this survey are described in publications *California Water Plan Update* (Bulletin 160-93, Volume 1, Chapter 6), and *Urban Water Use in California* (Bulletin 166-4, Appendix F). The California Department of Health Services conducted another survey in 1990, and three others were conducted by a private consulting firm in 1993, 1995, and

1997. (Unfortunately, the 1993 - 1997 surveys were based on an assumed monthly consumption of 1,500 cubic feet of water per connection, an amount much lower than that used by many households.) At a statewide level of coverage, there are no recent retail pricing data based on actual water use amounts.

In 1994, the accounting firm of Ernst & Young conducted a national water rates survey, which MWDSC summarized in its 1995 Integrated Resources Plan. That survey showed that the national average for urban water supply costs was almost $600 per acre-foot. The MWDSC average was about $625/af, with San Francisco at about $560/af, and Oakland at almost $700/af. (For comparison, other urban areas had greater water supply costs. Indianapolis, Indiana costs were about $725/af; Houston, Texas was almost $900/af, and Nashville, Tennessee was more than $1,100/af.)

Impacts of Retail Prices on Water Use

Price elasticity studies are used to characterize price responsiveness--the degree that water users increase or decrease use in response to a change in water price. The interpretation of elasticity studies must be done with care because of the large number of critical factors that can influence elasticity estimates.

Price Elasticity of Demand

The price elasticity of demand is the ratio of the percentage change in quantity of water used to the percentage change in the price of water.

When faced with a significant water price increase, urban residents may react in one of three ways:

- They may use substantially less water. In this case, the water users are more sensitive to price changes, and demand is said to be *elastic* (absolute elasticity value equal to or greater than one).
- They may use a little less water. In this case, the water users are less sensitive to price changes, and demand is said to be *inelastic* (absolute elasticity value less than one).
- They may continue to use the same amount as before. In this case, the water users are completely insensitive to price changes, and demand is said to be *perfectly inelastic* (elasticity value equal to zero).

In 1989, an East Bay Municipal Water District study estimated the price elasticity of

demand for residential water to be a negative 0.202 from 1981 through 1987. This means that a water price increase of 10 percent could be expected to lower the amount of water use by about 2 percent. In this case the demand for water is inelastic; residential water users were found to be relatively insensitive to price changes. This has been the case for most studies of residential water demand.

Factors That Affect the Price Elasticity of Residential Water Demand

Factors that can affect elasticity include climate, housing type, water users' income, percentage share of water bills in users' budgets, water rate structure, customer use of water conservation measures, water conservation education, and user preferences concerning water use (e.g., some users may prefer to irrigate large turf areas irrespective of costs). Elasticity estimates derived for one geographic area are not necessarily representative of another area, because of these many potential variables.

Recent Studies of the Urban Price Elasticity of Demand

Table 4A-2 provides a survey of recent literature from which the urban water price elasticities of demand were derived. These studies were made using statistical modeling which employed historical water use, water price, and other demographic and climatic data. The results developed from these studies are based on historical data specific to a particular set of circumstances. Using the results out of that context can lead to serious misinterpretations.

The California Urban Water Conservation Council published comprehensive guidebooks in 1994 and 1997 on setting urban water rates.

Table 4A-2. Studies of Urban Water Demand Price Elasticity

Author (s)	Study Date	Study Area	Type of Demand	Estimated Elasticity	Range of Study Water Prices	$/af Equivalent Prices ($1995)
Metzner[1]	1989	San Francisco	Long-run residential	-0.25	$0.73 - $0.78 /100 cu ft ($1995)	$318 - $340
Metropolitan Water District of Southern California	1990	South Coast Region	Long-run single-family residential Summer Winter	-0.29 to -0.36 -0.03 to -0.16	Not Available	Not Available
Nieswiadomy & Molina	1989	Denton, Texas	Long-run residential	-0.55 to -0.86	$0.27 - $0.56 /1000 gal ($1967)	$371 - $770
Weber	1989	East Bay MUD	Long-run residential	-0.01 to -0.25	$0.24 - $0.94 /100 cu ft ($1989)	$123 - $483
Schneider & Whitlach	1991	Columbus, Ohio	Short-run residential Long-run residential Short-run total urban Long-run total urban	-0.262 -0.110 -0.504 -0.123	Not Available	Not Available
Moncur	1987	Honolulu, Hawaii	Short-run residential Long-run residential	-0.265 -0.345	$0.22 - $0.36 /1000 gal ($1983)	$105 - $172
Billings & Day	1989	Tucson, Arizona	Long-run residential	-0.72	$6.60 - $11.20 monthly bills 1974 - 1980 ($1974)	$19 - $32 monthly bills

1. Water rate data was unavailable from the study author. DWR retrieved the historical data and inflated the prices to 1995 levels for display purposes only.

Agricultural Water Costs

In December 1996, the Department mailed water cost surveys to more than 60 selected agricultural water agencies in California. This survey was conducted to determine the range of average agricultural retail water costs in the State and to obtain information on the types of water charges that were being used by the water agencies. Table 4A-3 summarizes the results of this survey by hydrologic region. The survey also collected information concerning the type of water rates used by the agencies. Many of the responding agencies used a combination of charges based upon the amount of water used and the number of acres irrigated. Given the large number of agricultural water suppliers in California, the results of this small sample cannot be considered to have any statistical significance. Rather, the information is presented here to illustrate the variability of prices based on local circumstances.

Table 4A-3 . DWR Survey of 1996 Agricultural Surface Water Costs [1,2]

			1996 Costs ($/af)			How Agencies Charge for Water			
Hydrologic Region	Number of Water Agencies	1996 Total Deliveries (taf)	Weighted Average	Max.	Min.	By Acre	By Crop & Acre	By af Used	By Acre & af Used
North Coast	3	80	10	12	2	2	0	1	0
Central Coast	4	37	128	533	87	0	0	2	2
South Coast	8	92	373	604	131	0	0	1	7
Sacramento River	8	1,275	12	32	2	1	4	1	2
San Joaquin River	7	1,339	22	238	6	2	0	1	4
Tulare Lake	11	2,672	42	161	9	1	0	4	6
South Lahontan	1	18	61	61	61	0	0	1	0
Colorado River	4	3,403	13	14	8	2	0	0	2
Statewide	**46**	**8,916**		---	---	**8**	**4**	**11**	**23**

(1) Average retail costs to the farmer

(2) No responses were received from the San Francisco Bay and North Lahontan Regions.

Table 4A-4. Average Water Costs as a Percent of Total Production Costs for Selected Crops in the Tulare Lake Region

Crop	*Water Costs as a Percent of Total Costs*
Irrigated pasture	36
Alfalfa hay	19
Safflower	11
Barley	16
Dry beans	14
Wheat	14
Cotton	12
Sugar Beets	12
Dry Onions	9
Almonds	6
Pistachios	6
Processing tomatoes	6
Wine grapes	5

If surface water rates increase considerably, a farmer may switch to groundwater, at least over the short term. However, in areas such as the west side of the San Joaquin Valley, the groundwater quality is often inferior to that of surface water. Substitution of poorer-quality ground water for increasingly-costly surface water may require farmers to grow less profitable, salt-resistant crops, such as safflower. Over time, continued reliance upon groundwater may also result in declining groundwater levels, thereby increasing energy costs. Table 4A-4 provides an example of water costs as a percent of total production costs for some common crops in the Tulare Lake region. The data come from output of the Department's Central Valley Net Crop Revenue Model.

Agricultural groundwater costs vary considerably throughout California. Many factors influence these costs, including depth to groundwater, water quality, well yields, and electricity rates. Many groundwater users are self-supplied, meaning that individual water users pump their own supplies rather than receiving them from a water agency. Bulletin 160-93 showed some very general ranges of agricultural groundwater production. The Department does not have sufficient new data to accurately update those general cost ranges for Bulletin 160-98.

Impacts of Price on Agricultural Water Use

Price elasticity of demand for agricultural water is a measure of farmers' responsiveness to changes in the price of water. Researchers have used a variety of models (programming and econometrics) to estimate the price elasticity of irrigation water demand in different regions of the country, and they have concluded that the demand for irrigation water is generally price inelastic, at least within price ranges typical for agricultural water users. In order to estimate the price elasticity of demand for water in California's Central Valley for this Bulletin, a mathematical programming model called Central Valley Production Model was used. CVPM price elasticity estimates for irrigation water demand are based on the level of production of various crops. CVPM also allows for changes in the cropping pattern as water becomes more scarce, more expensive, or both.

To estimate the price elasticity of demand for surface water demand, the Central Valley was divided into three regions: Sacramento, San Joaquin, and Tulare. Surface water prices were increased for this study by different increments while ground water costs increased as a result of changes in pumping depths. Both short- and long-run elasticities were estimated for these regions. In the short-run study, it was assumed that farmers did not have enough time to adjust to the increases in water costs, while in the long-run farmers could switch to more efficient irrigation technologies. Results of this modeling run are summarized in Table 4A-5. Demand is considered to be elastic if the elasticity value is greater than or equal to one. Demand is inelastic if the elasticity value is less than one. If the elasticity value is zero, demand would be perfectly inelastic.

The values in the table are estimates of the farmer's ability to respond to water price changes. For example, if surface water prices increase by 10 percent in the Sacramento Valley, the demand for surface water will decline by 3.2 percent. As the estimates indicate, demand for irrigation water is "price inelastic," which means the percentage decline in quantity demanded is less than the percentage increase in price. Short-run elasticities were smaller than the long-run elasticities, implying that in the short-run water use will not change as much as in the long-run. Where groundwater is available in the Central Valley, farmers are likely to use more groundwater in response to increased surface water prices. Since groundwater was not included in the model, this implies that overall elasticities for irrigation water -- within a price range

typical for agricultural water users -- are even smaller than those shown.

Table 4A-5. Price Elasticities of Demand for Surface Water for Irrigation

Region	*Short-run Elasticity*	*Long-run Elasticity*	*Range of Water Prices ($/af)*
Sacramento	-0.24	-0.32	$20 - $240
San Joaquin	-0.2	-0.3	$20 - $240
Tulare	-0.18	-0.24	$20 - $240

Comparing Agricultural and Urban Water Costs

Direct comparisons between agricultural and urban water prices are misleading because of basic differences in the delivery systems providing agricultural and urban water supplies. Generally, the price of water is determined by the cost of water at the source (from a reservoir or at the Delta) plus the costs of using the facilities associated with conveying, storing, treating and delivering the water to the final users.

Source and Reliability Costs

Some contracts for agricultural supplies have allowed agricultural users to pay a lower price for water supplies in return for accepting supplies with a lower level of reliability. Typically this was achieved by deficiency provisions incorporated in the water supply contracts.

Transportation Costs

Both urban and agricultural water agencies must pay transportation costs incurred to bring the water supplies into their agencies. However, agricultural agencies are often closer to the surface water sources and in many cases are able to rely on gravity-operated conveyance and distribution systems, thereby avoiding energy costs associated with pressurized pipelines. Urban water supplies often travel through hundreds of miles of canals or pipelines, adding considerably to the transportation costs. For example, by the year 2000, power costs to deliver SWP water to the San Joaquin Valley service area are estimated to be at $15 per acre-foot; however, power costs to deliver the same acre-foot of SWP water to the South Bay, Central Coast, and Southern California service areas are estimated to be at $34, $78, and $87 per acre-foot, respectively.

Delivery Costs

Urban water systems have additional delivery costs compared to agricultural systems. For example, urban water users must pay for the terminal storage and pressurization of water.

Monitoring and treating water for public health protection is expensive, and costs are expected to increase as a result of more stringent drinking water standards. Most urban water systems also incur substantial costs to install and read meters, and to prepare billings.

Appendix 4B
BMP Revisions

Table 4B-1 provides a synopsis of revisions to urban water conservation BMPs, as adopted by CUWCC in September 1997.

Table 4B-1. BMP Revisions

A Synopsis of Proposed Changes to Existing BMP Definitions, Implementation Schedules, Coverage Requirements, and Reporting Requirements Contained in Exhibit 1 of the MOU

BMP Number	BMP Name	Changes to BMP Definition	Changes to Implementation Schedule	Changes to Coverage Requirement	Changes to Reporting Requirement
1	Water Audit Programs for Single-Family and Multi-family Residential Customers	Removes requirement to specifically target top 20% of residential water users. Allows agencies to develop targeting and marketing approaches tailored to their service areas. Specifies minimum audit elements. Requires agencies to develop database to track program.	Extends the implementation schedule 10 years from the date the BMP is revised or the date an agency signs the MOU, whichever is later.	Replaces the requirement that 70% of the top 20% of resi-dential customers accept an audit by September 1, 2001, with the requirement that 15% of residential customers accept an audit within 10 years of the date of implementation for the agency.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports.
2	Residential Plumbing Retrofit	Adds requirement that agencies maintain device distribution programs at levels sufficient to distribute retrofit kits to not less than 10% of residential accounts each reporting period until coverage requirement is met. Allows agencies to use mass distribution methods as appropriate. Allows agencies to develop targeting and marketing approaches tailored to their service areas. Requires agencies to develop data-base to track program.	Replaces the requirement that agencies realize the coverage requirement by September 1, 2001 with the requirement that they maintain the program at specified level until they can demonstrate coverage requirement is met.	Replaces the requirement that 75% of single-family and 80% of multi-family residences constructed prior to 1980 are retrofitted with the requirement that 75% of single-family and multi-family residences constructed prior to 1992 are retrofitted.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports.

Table 4B-1. BMP Revisions

A Synopsis of Proposed Changes to Existing BMP Definitions, Implementation Schedules, Coverage Requirements, and Reporting Requirements Contained in Exhibit 1 of the MOU

BMP Number	BMP Name	Changes to BMP Definition	Changes to Implementation Schedule	Changes to Coverage Requirement	Changes to Reporting Requirement
3	System Water Audits, Leak Detection and Repair	Replaces requirement that agencies conduct a complete system audit every three years with requirement that agencies conduct annual pre-screen audits and conduct full system audits only if indicated by the pre-screen audit.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later.	No change.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports.
4	Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections	Adds requirement that agencies assess feasibility of program to retrofit mixed-use metered accounts with dedicated irrigation meters.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later Extends date that coverage requirement must be met from September 1, 2001, to 10 years from the date the BMP is revised or the date an agency signs the MOU, whichever is later	No change.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports.

Table 4B-1. BMP Revisions

A Synopsis of Proposed Changes to Existing BMP Definitions, Implementation Schedules, Coverage Requirements, and Reporting Requirements Contained in Exhibit 1 of the MOU

BMP Number	BMP Name	Changes to BMP Definition	Changes to Implementation Schedule	Changes to Coverage Requirement	Changes to Reporting Requirement
5	Large Landscape Conservation Programs and Incentives	Adds requirement that agencies develop water use budgets for accounts with dedicated irrigation meters. Removes requirement to specifically target landscapes of 3+ acres for audits. Continues to require audits for customers without landscape water use budgets. Continues to require customer incentive programs. Allows agencies to develop targeting and marketing approaches tailored to their service areas. Requires agencies to develop database to track program.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later. Allows agencies 10 years from date BMP implementation is to be underway to meet coverage requirement. Allows agencies four years to develop water use budgets for dedicated irrigation meter accounts.	Removes requirement that agencies offer audits to 100% of accounts with 3+ acres of landscape by September 1, 2001. Adds requirement that agencies provide landscape audits to 15% of mixed-use, non-residential accounts within 10 years from date BMP implementation is to be under-way for agency. Adds requirement that agencies offer audits to not less than 20% of mixed-use, non-residential accounts each reporting period. Allows agencies to satisfy audit requirements by implementing a mixed-use meter retrofit program or a program to develop landscape water use budgets for accounts with mixed-use meters.	Requests data on the number of accounts with dedicated irrigation meters, and number of water budgets established during reporting period. Otherwise, requests similar types and amounts of information as is currently being collected by CUWCC annual reports.
6 (New)	High-Efficiency Washing Machine Rebate Programs	Adds requirement that agencies offer maximum cost-effective customer rebate for high-efficiency washing machine if energy service provider in service area is also offering rebates.			

Table 4B-1. BMP Revisions

A Synopsis of Proposed Changes to Existing BMP Definitions, Implementation Schedules, Coverage Requirements, and Reporting Requirements Contained in Exhibit 1 of the MOU

BMP Number	BMP Name	Changes to BMP Definition	Changes to Implementation Schedule	Changes to Coverage Requirement	Changes to Reporting Requirement
7	Public Information Programs	Adds requirement that agencies conduct public awareness surveys every three years to assess conservation attitudes and guide program design.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later.	No change.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports
8	School Education Programs	No substantive changes.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later.	No change.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports.
9	Conservation Programs for Commercial, Industrial, and Institutional Accounts	Replaces audit requirement with a two track approach; an agency can choose either to implement an audit program for CII customers, or to meet a water savings performance target for the CII sector. Requires CUWCC to develop long-term CII ULFT implementation targets based on findings of CUWCC CII ULFT Water Savings Study within one year of BMP adoption.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later. Allows agency 10 years from date implementation is to commence to meet coverage requirement.	Requires either 10% of commercial, industrial, and institutional accounts to accept an audit within 10 years or a reduction in water use by commercial, industrial, and institutional accounts by an amount equal to 10% of the use by the top 10% of accounts.	Requires agencies to substantiate either completed audits or water savings estimates. Requests substantially more information on program design and implementation than what is currently being collected through annual reports by the CUWCC.

Table 4B-1. BMP Revisions

A Synopsis of Proposed Changes to Existing BMP Definitions, Implementation Schedules, Coverage Requirements, and Reporting Requirements Contained in Exhibit 1 of the MOU

BMP Number	BMP Name	Changes to BMP Definition	Changes to Implementation Schedule	Changes to Coverage Requirement	Changes to Reporting Requirement
10 (New)	Wholesale Agency Assistance Programs	Defines wholesale agency support roles in terms of financial, technical, and programmatic assistance to retail agencies implementing BMPs.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later.	Requires wholesalers to justify financial, technical, and programmatic support levels.	Requires additional reporting by wholesale agencies over what is currently being collected through annual reports by the CUWCC.
11	Conservation Pricing	Retains current definitions of non-conserving and con-serving rate structures. Adds requirement that CUWCC undertake a study to empirically assess the affect of rate structure on customer water use patterns and quantities, and to specifically examine the relationship between customer demand and the proportion of agency revenue requirement recovered through commodity charges, fixed charges, and other service charges.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later.	No change.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports.
12 (formerly BMP 14)	Conservation Coordinator	No substantive change.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later.	No change.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports.

Table 4B-1. BMP Revisions

A Synopsis of Proposed Changes to Existing BMP Definitions, Implementation Schedules, Coverage Requirements, and Reporting Requirements Contained in Exhibit 1 of the MOU

BMP Number	BMP Name	Changes to BMP Definition	Changes to Implementation Schedule	Changes to Coverage Requirement	Changes to Reporting Requirement
13 (formerly BMP 16)	Residential ULFT Replacement Programs	Removes reference to CII ULFT replacement requirements; otherwise no substantive change.	Makes implementation schedule relative to the date the BMP is revised or the date an agency signs the MOU, whichever is later. Allows agency 10 years from date implementation is to commence to meet coverage requirement.	No change.	Requests similar types and amounts of information as is currently being collected by CUWCC annual reports.

Appendix 6A. Estimating a Water Management Option's Cost Per Acre-Foot

A key consideration in the options evaluation process is the appraisal of costs, both financial and economic. *Financial costs* are the actual yearly dollar expenditures that are required to repay debt (with interest) incurred to finance the capital costs of a project and to meet operations, maintenance and replacement costs. Generally, financial costs are spread over a shorter time period than the life of the project (often 20 to 30 years). In comparison, *economic costs* reflect the costs of resources committed to the construction and operation of a project over its life, which can be 50 years or more for many water resources options. It is possible for options to be economically feasible and financially infeasible, or vice versa.

This appendix focuses upon economic costs. Although economic costs can be expressed in many different ways, a useful statistic is the economic cost per acre-foot of option delivery (cost/af). The mathematical computation of cost/af is not necessarily difficult, but there are a number of significant issues which complicate the process. Some of these issues apply to all of the options (for example, data availability), whereas others are specific to particular types of options (for example, reservoir operational characteristics).

Common Cost Issues

Cost issues common to all options include data availability and method of analysis:

Data Availability. The cost/af estimate requires extensive data on the option's costs as well as its performance given assumptions concerning hydrology and how the option will be operated.

- **Costs.** Costs include *capital* and *annual operations, maintenance and replacement costs.* Capital costs are associated with the construction and implementation of the option (including any needed transportation and treatment facilities). Examples of capital costs include expenditures for planning, design, right-of-way, and construction as well as allowances for environmental mitigation costs. Capital costs also include activation costs (operation and maintenance expenditures prior to operations) and filling costs. OM&R costs (which begin when construction is completed and project operations begin) include annual operation and maintenance costs (such as administration, maintenance, energy,

water purchases, treatment, etc.) and replacement costs incurred during the normal course of project operations. Capital and OM&R costs must be identified down to the user level, which can include costs associated with storage, transportation, treatment and distribution and costs incurred by the users themselves.

- **Hydrology.** For many options (such as surface water reservoirs and groundwater/conjunctive use projects), hydrology is key to understanding the option's performance given certain operating assumptions. Some options are expected to be operated to provide maximum deliveries during non-shortage years but minimal deliveries during shortage years (such as some surface water reservoirs); others are designed to provide maximum deliveries during shortage years with minimal deliveries during non-shortage years (such as some ground water/conjunctive use projects); and others can provide a relative constant supply regardless of type of year (for example, water recycling).

Because much of the focus of this Bulletin is upon local options, the cost/af estimates are dependent upon cost and hydrology data available in existing reports and other documents prepared by water agencies. Some of the difficulties that arise in using this information include:

- Data are inconsistent among the agencies (for example, different hydrologic time periods are used);
- Data are either missing or incomplete (sometimes capital costs are reported, but not operating costs);
- Data may be available, but it is uncertain what it means (for example, do reported total capital costs include environmental mitigation costs?);
- Data were developed at different times (information on some options is relatively new, while other data may be 30 years or more old); and
- Data were developed at different levels of study (appraisal level data is being compared to feasibility level information).

Since our intent is to examine options from a statewide perspective at an appraisal level of detail, our approach has been to acknowledge that these difficulties exist, but to use the available information. The scope of this Bulletin does not permit us to develop new information for all of the literally hundreds of options for which data were collected. We have focused our

efforts on normalizing costs of the statewide options and larger local options.

Assumptions. Cost/af estimates will vary depending upon the assumptions used in the calculation. For this Bulletin, the following assumptions are used in developing the cost/af estimates:

- **Period of analysis.** Two analysis periods are used: a 50 year period is used for capital-intensive options (such as dams, reservoirs, water treatment plants, desalination plants, and conjunctive use) and a 25 year period is used less capital-intensive options (such as demand management).
- **Inflation and cost escalation.** The analysis uses constant dollars (i.e., it excludes price changes occurring as a result of inflation). Real price changes (net price changes after accounting for inflation) are used if significant. For example, if energy prices are projected to differ substantially from general price level changes (and if the option is energy-intensive) then it would be appropriate to account for this energy price differential.
- **Discount rate**. This interest rate is used to reflect the time value of money. Even if inflation is not expected to be present, a dollar received today is worth more than a dollar expected in the future, because a dollar received today can be put to immediate use. The discount rate adjusts the dollar values received or spent over a period of time to their "present value" equivalent. This Bulletin uses a 6 percent discount rate.
- **Base year.** All dollar values are converted to constant 1995 dollars using the USBR cost index or other cost indices as appropriate.
- **Probabilities.** Assumed probabilities for the occurrence of shortage (dry or critical years) and non-shortage (below average or wetter) years statewide are 80 and 20 percent, respectively. However, if regional information is available, it may be used instead of these values.

Method of Analysis. For this Bulletin, a spreadsheet was developed to do the cost/af computation. This spreadsheet was designed to be as flexible as possible given data availability problems. Table A-1 shows the results of an example cost/af analysis for four hypothetical water management options using this spreadsheet: a groundwater recharge/conjunctive use project, a surface water reservoir, a water recycling project and a contingency shortage measure. The

groundwater recharge/conjunctive use project is assumed to deliver about 15,000 acre-feet during shortage years, but none during non-shortage years. The surface water reservoir is assumed to deliver about 10,000 acre-feet in non-shortage years, but only 3,000 acre-feet in a shortage year. In comparison, the water recycling project is expected to deliver about 3,000 acre-feet for all types of years. About 2,000 acre-feet of water is assumed to be available through water transfers during shortage years. With the capital and annual variable operating costs assumed in the table, the cost/af estimates for the groundwater recharge/conjunctive use, water transfers, water recycling project and surface water reservoir are estimated to be about $150, $250, $710, and $800 respectively.

Table 6A-1. Economic Cost/af Examples (1)

Option	Option Delivery (1000 af)		Probabilities (%)		Capital Costs ($Mill)	Annual Variable Costs ($Mill)		Cost/af
	Shortage Year(2) (a)	Non-Shortage Year (2) (b)	Shortage Year(2) (c)	Non-Shortage Year (2) (d)	(e)	Shortage Year(2)	Non-Shortage Year (2) (g)	(h)
Groundwater Recharge/Conjunctive Use	15.0	0.0	20.0%	80.0%	$4.0	$0.6	$0.1	$150
Water Transfers (3)	2.0	0.0	20.0%	80.0%	$0.0	$0.5	$0.0	$250
Water Recycling	3.0	3.0	20.0%	80.0%	$24.0	$0.6	$0.6	$710
Surface Water Reservoir	3.0	10.0	20.0%	80.0%	$80.0	$2.0	$1.0	$800

(1) 50 years; 6% discount rate.

(2) Shortage years include dry or critical years; non-shortage years include below average or wetter years.

(3) Using existing facilities.

Option-Specific Cost Issues

Many options have cost calculation issues that are specific to the option type.

Conservation. In addition to quantifying the amount of demand reduction that can be achieved by conservation measures, another issue is costs, especially from the water user perspective. In order to achieve savings from many of the conservation options (such as landscaping, toilet retrofits, or installation of drip irrigations systems), water users, rather than water districts, must purchase additional equipment. Because of the substantial user costs of some conservation options, they must be addressed in the cost/af estimate. For example, a landscaping option could require installation of low-water using plants, which would include

costs of the plants, their installation, and possibly the removal of existing landscaping. Since our options evaluation process is focused on costs from the water agency perspective, we are assuming that conservation programs requiring substantial user investments will be implemented only to the extent that the programs are financed by water agencies, and that the programs' costs include reimbursement of users' expenditures.

Water Recycling. Although water quality is important for all options, it is especially critical for water recycling. With water recycling, the final use of the recycled water is dependent upon the level of treatment it receives, which in turn directly affects the cost of the recycled water. Costs are associated with the treatment facilities as well as with distribution, which can be substantial since a separate set of plumbing is required and the treatment plant may be a considerable distance from the final place of use. As with conservation options, supplies developed through water recycling should not be significantly affected by hydrology.

Groundwater/Conjunctive Use. Because groundwater/conjunctive use projects often involve many types of facilities, and are operated according to changes in hydrology, computing cost/af estimates can be more complex than for other types of options. Typically a groundwater/conjunctive use project requires a water source, either from a local surface supply, water treatment facility, or imported water. A conveyance facility is required to transport the water to the recharge facility, which might include recharge ponds and/or injection wells. Extraction wells are required to recover the recharged supplies, and conveyance facilities are required to deliver the supplies back into the water agency's existing system. Hydrology is key to the operation of many groundwater/conjunctive use projects, because typically the recharge portion of the project is operated in non-shortage years, whereas the extraction portion is operated in shortage years. Facilities may not be operated during years where there is not enough water for recharge, or when conditions are not dry enough to warrant extractions. Although the capital costs of a groundwater/conjunctive use project are not significantly influenced by hydrology, the annual operating and maintenance costs are especially sensitive to it because of pumping costs. The cost/af estimate can be further complicated because these types of projects are often operated in conjunction with other facilities (typically surface water reservoirs), hence affecting the costs of those facilities as well.

Surface Water Reservoirs. A critical issue with reservoirs concerns how they will be

operated. Some reservoirs are operated to maximize water supplies during average years, whereas others are operated for drought shortage years or emergency storage purposes (MWDSC's Eastside Reservoir, for example). Although the capital cost to construct a reservoir may be the same regardless of the method of its operation, the cost/af estimate will differ substantially among these operational modes. A reservoir's operating and maintenance can be expected to vary significantly depending upon whether it provides on-stream or off-stream storage (the latter type will likely have substantial energy costs associated with reservoir filling). Of all the supply augmentation options, reservoirs are the most likely to provide substantial benefits other than water supply (such as recreation, flood control and power generation). However, as long as the primary purpose of the reservoir is water supply, no attempt is made in this Bulletin to separate the costs of the different purposes.

Water Transfers. Because water transfers (both short and long-term) often involve the movement of water from one region to another, costs can be identified for both the *exporting* and *importing* regions. Costs in the exporting region will be influenced by the source of the water, from agricultural land fallowing, crop shifts, water conservation, groundwater substitution, groundwater development, and/or surface water withdrawals. All of these sources not only have the potential for the direct loss of economic activity that could have otherwise been supported by the transferred water, but also indirect economic effects (third party impacts). For the importing regions, water transfers not only include the water purchase and transportation costs but also may require the payment of option fees. Option fees are paid by a contracting agency to a selling agency to maintain the right of the contracting agency to buy water whenever needed. Although the water may not be purchased every year, the fee is usually paid every year. Other issues which can affect the costs of water transfers to the importing region include the availability of conveyance capacity and (for north-south transfers) the difficulties associated with routing the transferred water through the Delta.

Appendix 6B.
Ratings of Alternative South-of-Delta Reservoir Sites

Dam Site	Potential Range of Storage Volume (1,000 Acre-Feet)	Unit Cost of Storage ($ per acre-foot)	Cost Rating (0 - 100)	Environmental Sensitivity Rating (0 - 100)	Combined Total Rating (0 - 100)
Very Large Reservoirs (1.0 to 2.0 MAF Storage Volume)					
LBG / Los Banos Creek (Dam 181)	1,000 - 2,000	730 - 550	76 - 82	31 - 31	53 - 56
Garzas Creek (Dam 104)	1,000 - 1,750	1,600 - 1,310	47 - 56	53 - 52	50 - 54
Panoche/Silver Creek (Dam 114)	1,000 - 2,000	1,370 - 1,210	54 - 60	47 - 45	51 - 52
Orestimba Creek (Dam 171)	1,000 - 1,140	1,670 - 1,600	44 - 47	46 - 46	45 - 46
Large Reservoirs (0.5 to 1.0 MAF Storage Volume)					
LBG / Los Banos Creek (Dam 181)	500 - 1,000	1,000 - 730	67 - 76	33 - 31	50 - 53
Panoche/Silver Creek (Dam 112)	500 - 1,000	1,620 - 1,320	46 - 56	49 - 47	48 - 52
Panoche/Silver Creek (Dam 114)	500 - 1,000	1,830 - 1,370	39 - 54	48 - 47	44 - 51
Ingram Canyon (Dam 37)	500 - 980	1,950 - 1,400	35 - 53	48 - 48	42 - 51
Orestimba Creek (Dam 170)	500 - 900	1,890 - 1,410	37 - 53	49 - 46	43 - 50
Garzas Creek (Dam 104)	500 - 1,000	2,090 - 1,600	30 - 47	54 - 53	42 - 50
Garzas Creek (Dam 105)	500 - 630	1,910 - 1,660	36 - 45	54 - 54	45 - 49
Panoche/Silver Creek (Dam 45)	500 - 990	2,300 - 1,920	23 - 36	59 - 57	41 - 47
Garzas Creek (Dam 109)	500 - 940	2,250 - 1,730	25 - 42	54 - 52	40 - 47
Orestimba Creek (Dam 171)	500 - 1,000	1,930 - 1,670	36 - 44	48 - 46	42 - 45
Medium Reservoirs (0.25 to 0.5 MAF Storage Volume)					
LBG / Los Banos Creek (Dam 181)	250 - 500	1,660 - 1,000	45 - 67	35 - 33	40 - 50
Panoche/Silver Creek (Dam 112)	250 - 500	2,250 - 1,620	25 - 46	49 - 49	37 - 48
Sunflower Valley (Dam 177)	250 - 500	2,490 - 1,460	17 - 51	46 - 44	31 - 48
Garzas Creek (Dam 106)	250 - 310	2,050 - 1,820	32 - 39	54 - 54	43 - 47
Garzas Creek (Dam 105)	290 - 500	2,400 - 1,910	20 - 36	54 - 54	37 - 45
Panoche/Silver Creek (Dam 114)	250 - 500	2,050 - 1,830	32 - 39	49 - 48	40 - 44
Orestimba Creek (Dam 170)	250 - 500	2,630 - 1,890	12 - 37	50 - 49	31 - 43
Garzas Creek (Dam 104)	250 - 500	2,950 - 2,090	2 - 30	55 - 54	28 - 42
Orestimba Creek (Dam 171)	250 - 500	3,000 - 1,930	0 - 36	49 - 48	24 - 42
Ingram Canyon (Dam 37)	250 - 500	3,120 - 1,950	N/A - 35	49 - 48	N/A - 42
Small Reservoirs (0.10 to 0.25 MAF Storage Volume)					
Kettleman Plain (Dam 99)	100 - 250	2,990 - 1,620	0 - 46	61 - 59	30 - 53
Garzas Creek (Dam 106)	100 - 250	3,300 - 2,050	N/A - 32	56 - 54	N/A - 43
Garzas Creek (Dam 107)	100 - 250	3,300 - 2,020	N/A - 33	56 - 54	N/A - 43
Panoche/Silver Creek (Dam 111)	100 - 240	3,480 - 2,020	N/A - 33	51 - 49	N/A - 41
LBG / Los Banos Creek (Dam 181)	100 - 250	3,350 - 1,660	N/A - 45	37 - 35	N/A - 40
Panoche/Silver Creek (Dam 114)	100 - 250	3,560 - 2,050	N/A - 32	51 - 49	N/A - 40
Little Salado/Crow Creek (Dam 63)	100 - 130	2,810 - 2,310	6 - 23	49 - 48	28 - 36
Quinto Creek (Dam 54)	110 - 250	3,120 - 2,370	N/A - 21	50 - 49	N/A - 35
Romero Creek (Dam 56)	100 - 180	3,410 - 2,560	N/A - 15	53 - 53	N/A - 34
Garzas Creek (Dam 108)	100 - 250	4,010 - 2,870	N/A - 4	56 - 55	N/A - 30

Appendix 7A

Table 7A-1. Options Evaluation North Coast Region

Option	Evaluation Scores							Rank
	Engineering	Economics	Environ-mental	Institutional/ Legal	Social/ Third Party	Other Benefits	Overall Score	
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	3	3	1	**16**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	1	1	1	**11**	**L**
Interior CII Water Use (2%)	2	2	4	2	3	1	**14**	**M**
Interior CII Water Use (3%)	2	1	4	2	1	1	**11**	**L**
New Reservoirs/Conveyance Facilities								
Smaller Reservoir (@ Boddy property site or alternate location)	3	1	1	2	3	0	**10**	**L**
Waterfall Gulch Intake Improvement	3	3	4	3	3	0	**16**	**M**
South Basin (City of Fort Bragg)	3	3	3	3	3	0	**15**	**M**
Groundwater/Conjunctive Use								
New wells - Fort Bragg and other small Coastal Communities	3	4	4	4	3	0	**18**	**H**
Agricultural Groundwater Development	3	1	3	3	3	0	**13**	**M**
Desalination								
Brackish Groundwater								
City of Fort Bragg Project	4	2	3	3	3	0	**15**	**M**
Seawater								
City of Fort Bragg Project	3	0	3	3	3	0	**12**	**M**

Table 7A-2. Options Evaluation
San Francisco Bay Region

Option	Evaluation Scores							Rank
	Engineering	Economics	Environ-mental	Institutional/ Legal	Social/ Third Party	Other Benefits	Overall Score	
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	3	3	1	**16**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	1	1	1	**11**	**L**
Interior CII Water Use (2%)	2	2	4	2	2	1	**13**	**M**
Interior CII Water Use (3%)	2	1	4	2	1	1	**11**	**L**
Distribution System Losses (7%)	2	2	4	3	2	1	**14**	**M**
Modify Existing Reservoirs/Operations								
Enlarge Lake Hennessey / Napa River Diversion	4	2	2	3	4	1	**16**	**M**
Enlarge Bell Canyon Reservoir	3	2	2	2	4	2	**15**	**M**
Enlarge Bell Canyon Reservoir / Napa River Diversion	3	1	2	3	4	1	**14**	**M**
Raise Pardee Dam	4	3	2	2	2	3	**16**	**M**
Raise Camanche Dam	4	3	2	2	2	3	**16**	**M**
Enlarge Leroy Anderson Reservoir	4	0	2	3	3	2	**14**	**M**
Upgrade Milliken Treatment Plant	3	3	3	4	4	1	**18**	**H**
Reoperate Rector Reservoir	3	3	3	3	4	1	**17**	**H**
New Reservoirs/Conveyance Facilities								
Chiles Creek Reservoir Project / Napa River Diversion	4	2	2	3	3	1	**15**	**M**
Enlarge Lake Hennessey / Chiles Creek Project / Napa River Diversion	4	2	2	2	3	1	**14**	**M**
Carneros Creek Reservoir / Napa River Diversion	3	1	1	2	3	1	**11**	**L**
Upper Del Valle Reservoir	4	1	2	3	3	2	**15**	**M**

Table 7A-2. Continued

Buckhorn Dam and Reservoir	3	3	1	2	3	3	**15**	**M**
Upper Kaiser Reservoir	3	1	1	3	3	3	**14**	**M**
Upper Buckhorn Reservoir	3	1	1	1	2	3	**11**	**L**
Middle Bar Reservoir	3	3	1	2	2	3	**14**	**M**
Duck Creek Offstream Reservoir	3	3	1	2	2	3	**14**	**M**
Devils Nose Project	4	3	2	2	1	2	**14**	**M**
Folsom South Canal Connection Project	4	3	2	3	3	1	**16**	**M**
Groundwater/Conjunctive Use								
Milliken Creek Conjunctive Use	3	4	3	3	4	1	**18**	**H**
Lake Hennessey / Conn Creek Conjunctive Use	4	4	4	3	4	1	**20**	**H**
Water Transfers/Banking/Exchange								
Alameda County FC&WCD, Zone 7	4	4	4	4	3	0	**19**	**H**
Santa Clara Valley Water District	4	4	4	4	3	0	**19**	**H**
Water Recycling								
Group 1 (Cost < $500/AF)	3	4	3	3	3	1	**17**	**H**
Group 2 (Cost $500/AF - $1,000/AF)	3	3	3	3	3	1	**16**	**M**
Group 3 (Cost > $1,000/AF)	3	1	3	3	3	1	**14**	**M**
Desalination								
Brackish Groundwater								
Alameda County Water District Aquifer Recovery Project	3	3	2	3	3	0	**14**	**M**
Seawater								
Marin Municipal Water District Desalination Project	3	1	2	0	3	1	**10**	**L**
Other Local Options								
New Surface Water Diversion from Sacramento River by cities of Benicia, Fairfield, & Vallejo	3	3	2	2	3	0	**13**	**M**
Statewide Options								
CALFED Bay / Delta Program	3	1	2	2	3	4	**15**	**M**

Table 7A-2. Continued

SWP Interim South Delta Program	4	3	3	2	3	1	**16**	**M**
SWP American Basin Conjunctive Use Program	3	4	3	2	2	3	**17**	**H**
SWP Supplemental Water Purchase Program	2	3	2	2	2	0	**11**	**L**
Drought Water Bank	4	3	3	4	3	1	**18**	**H**
Enlarge Shasta Lake	3	1	2	2	2	2	**12**	**M**

Table 7A-3. Options Evaluation
Central Coast Region

Option	*Evaluation Scores*							*Rank*
	Engineering	*Economics*	*Environ mental*	*Institutional/ Legal*	*Social/ Third Party*	*Other Benefits*	*Overall Score*	
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	3	3	1	**16**	**M**
Outdoor Water Use - New and Existing Development	3	1	4	1	1	1	**11**	**L**
Interior CII Water Use (3%)	2	1	4	2	1	1	**11**	**L**
Modify Existing Reservoirs/Operations								
Modify Nacimiento Spillway	4	4	4	4	4	0	**20**	**H**
Inter-Lake Tunnel - Nacimiento/San Antonio Reservoirs	4	4	3	4	4	0	**19**	**H**
Enlargement of Salinas Reservoir	4	3	3	3	3	0	**16**	**M**
Enlargement of Cachuma Reservoir	2	1	3	3	3	0	**12**	**M**
New Reservoirs/Conveyance Facilities								
College Lake	3	3	2	1	3	3	**15**	**M**
Bolsa De San Cayetano Reservoir	3	2	2	1	3	0	**11**	**L**
Corncob Canyon Reservoir	3	2	2	1	3	0	**11**	**L**
Pescadero Reservoir	3	3	2	1	3	0	**12**	**M**
Gabilan Creek Dam	2	1	2	2	2	0	**9**	**L**
Feeder Streams (Various Sites)	2	2	3	2	3	0	**12**	**M**
Chalone Canyon Dam	3	2	3	3	3	0	**14**	**M**
Vaqueros Canyon Dam	3	1	1	2	2	0	**9**	**L**
New Los Padres Reservoir (24 taf)	4	3	3	1	3	2	**16**	**M**
New Los Padres Reservoir (11 taf)	4	2	3	2	3	2	**16**	**M**
Nacimiento Pipeline	3	2	3	3	3	0	**14**	**M**

Table 7A-3. Continued

Groundwater/Conjunctive Use								
College Lake Injection/Extraction Wells	3	4	3	3	3	0	**16**	**M**
Increase Groundwater Development in Seaside Basin	3	3	2	1	2	0	**11**	**L**
Water Transfers/Banking/Exchange								
CVP (San Felipe Project Extension)	3	2	3	2	3	1	**14**	**M**
Water Recycling								
Group 1 (Cost < $500/AF)	3	4	3	3	3	1	**17**	**H**
Group 2 (Cost $500/AF - $1,000/AF)	3	3	3	3	3	1	**16**	**M**
Group 3 (Cost > $1,000/AF)	3	1	3	3	3	1	**14**	**M**
Desalination								
Brackish Groundwater								
City of Santa Cruz	4	2	3	2	3	0	**14**	**M**
Seawater								
Monterey Peninsula Water Management District	3	1	3	0	2	0	**9**	**L**
Statewide Options								
CALFED Bay / Delta Program	3	1	2	2	3	4	**15**	**M**
SWP Interim South Delta Program	4	3	3	2	3	1	**16**	**M**
SWP Supplemental Water Purchase Program	2	3	2	2	2	0	**11**	**L**
Enlarge Shasta Lake	3	1	2	2	2	2	**12**	**M**

Table 7A-4. Options Evaluation
South Coast Region

Option	Evaluation Scores							Rank
	Engineering	Economics	Environ-mental	Institutional/ Legal	Social/ Third Party	Other Benefits	Overall Score	
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	3	3	1	16	M
Outdoor Water Use - New and Existing Development	3	1	4	1	1	1	11	L
Interior CII Water Use (2%)	2	2	4	2	2	1	13	M
Interior CII Water Use (3%)	2	1	4	2	1	1	11	L
Modify Existing Reservoirs/Operations								
Reoperate Prado Dam	3	4	4	3	3	0	17	H
Reoperate Hansen and Lopez Dams	3	3	3	2	3	0	14	M
Reoperate Santa Fe and Whittier Narrows Dams	3	3	3	2	3	1	15	M
New Reservoirs/Conveyance Facilities								
Freshwater Reservoir in Long Beach Harbor	2	1	2	2	3	0	10	L
Groundwater/Conjunctive Use								
Local Groundwater Banking/Conjunctive Use	4	3	4	3	4	0	18	H
Water Transfers/Banking/Exchange								
Colorado River Water Transfers/Interstate Banking (part of Colorado River 4.4 plan)	4	3	3	3	3	3	19	H
MWDSC / Arvin Edison WSD Groundwater Banking	4	4	4	2	2	0	16	M
Castaic Lake Water Agency	4	4	4	4	3	0	19	H
Water Recycling								
Group 1 (Cost < $500/AF)	3	4	3	3	3	1	17	H
Group 2 (Cost $500/AF - $1,000/AF)	3	3	3	3	3	1	16	M
Group 3 (Cost > $1,000/AF)	3	1	3	3	3	1	14	M

Table 7A-4. Continued

Desalination								
Brackish Groundwater								
Group 1 (Cost < $500/AF)	3	4	3	3	3	1	**17**	**H**
Group 2 (Cost $500/AF - $1,000/AF)	3	3	3	3	3	1	**16**	**M**
Seawater								
Reverse Osmosis Facilities at South Bay Power Plant	2	1	2	3	3	0	**11**	**L**
Reverse Osmosis Facilities at Encina Power Plant	2	0	2	3	3	0	**10**	**L**
Reverse Osmosis Facilities at Alamitos Power Plant	2	0	2	3	3	0	**10**	**L**
Multiple-effect Distillation Process	1	2	2	2	3	0	**10**	**L**
Statewide Options								
CALFED Bay / Delta Program	3	1	2	2	3	4	**15**	**M**
SWP Interim South Delta Program	4	3	3	2	3	1	**16**	**M**
SWP American Basin Conjunctive Use Program	3	4	3	2	2	3	**17**	**H**
SWP Supplemental Water Purchase Program	2	3	2	2	2	0	**11**	**L**
Drought Water Bank	4	3	3	4	3	1	**18**	**H**
Enlarge Shasta Lake	3	1	2	2	2	2	**12**	**M**

Appendix 8A. Interior Regions

Table 8A-1. Options Evaluation Sacramento River Region.

Option	Evaluation Scores							Rank
	Engineering	Economics	Environ-mental	Institutional/ Legal	Social/ Third Party	Other Benefits	Overall Score	
Modify Existing Reservoirs/Operations								
Reoperation of PG&E Reservoirs	3	3	2	0	1	0	**9**	**L**
New Reservoirs/Conveyance Facilities								
Dry Creek Reservoir (Lake County)	3	2	2	1	3	0	**11**	**L**
Bear Creek Reservoir (Colusa County)	3	2	2	2	3	1	**13**	**M**
Wilson Valley Reservoir (Lake County)	3	2	2	2	3	3	**15**	**M**
Blue Ridge Reservoir (Yolo County)	3	2	2	2	3	3	**15**	**M**
Thurston Lake Pump-Storage Project	2	1	2	2	2	2	**11**	**L**
Parks Bar Reservoir (Yuba County)	3	2	2	2	3	4	**16**	**M**
Waldo Reservoir (Yuba County)	4	3	3	3	3	2	**18**	**H**
Texas Hill Reservoir	3	2	2	2	2	1	**12**	**M**
Small Alder Reservoir	3	2	2	2	2	0	**12**	**M**
GDPUD Diversion from Middle Fork American River	3	1	2	2	2	0	**10**	**L**
Groundwater/Conjunctive Use								
New Wells (Redding, Butte, and Colusa basins)	4	4	3	4	3	0	**18**	**H**
USBR/Ducks Unlimited Conjunctive Use	3	4	3	3	3	3	**19**	**H**
Big Valley Conjunctive Use	3	3	3	2	3	2	**16**	**M**
Other Local Options								
New Surface Water Diversion from Sacramento River and Cache Creek by YCFC&WCD	3	3	2	2	3	0	**13**	**M**
New Surface Water Diversion from Sacramento River by cities of Benicia, Fairfield, and Vallejo (Vacaville)	3	3	2	2	3	0	**13**	**M**

Table 8A-1. Options Evaluation Sacramento River Region.

Statewide Options								
SWP American Basin Conjunctive Use Program	3	4	3	2	2	3	**17**	**H**
Auburn Dam	3	2	2	2	2	4	**15**	**M**
CVPIA Water Acquisition Program	4	3	3	3	2	0	**15**	**M**

Table 8A-2. Options Evaluation
San Joaquin River Region

Option	Evaluation Scores							Rank
	Engineering	Economics	Environ-mental	Institutional/ Legal	Social/ Third Party	Other Benefits	Overall Score	
Conservation								
Agricultural								
Flexible Water Delivery	3	0	4	3	2	1	**13**	**M**
Canal Lining and Piping	3	0	4	3	3	1	**14**	**M**
Tailwater Recovery	3	3	4	3	3	1	**17**	**H**
Modify Existing Reservoirs/Operations								
Reoperate/Enlarge Farmington Reservoir	2	2	3	3	3	3	**16**	**M**
New Reservoirs/Conveyance Facilities								
Montgomery Reservoir Offstream Storage	3	3	3	2	3	3	**17**	**H**
Fine Gold Creek Offstream Storage	3	2	2	2	3	3	**15**	**M**
Irish Hill Reservoir	3	2	2	1	3	1	**12**	**M**
Volcano Reservoir	3	2	2	1	3	1	**12**	**M**
Middle Bar Reservoir (159 taf yield)	3	1	2	1	2	1	**10**	**L**
Devil's Nose Reservoir	3	1	2	1	2	1	**10**	**L**
Statewide Options								
Auburn Dam	3	2	2	2	2	4	**15**	**M**
Enlarge Friant Dam	3	2	2	2	3	4	**16**	**M**
CVPIA Water Acquisition Program	4	3	3	3	2	0	**15**	**M**

Table 8A-3. Options Evaluation Tulare Lake Region

Option	Evaluation Scores							Rank
	Engineering	Economics	Environ-mental	Institutional/ Legal	Social/ Third Party	Other Benefits	Overall Score	
Conservation								
Agricultural								
Irrigation Efficiency Improvements (78%)	4	4	2	4	3	1	**18**	**H**
Irrigation Efficiency Improvements (80%)	3	3	2	3	2	1	**14**	**M**
Modify Existing Reservoirs/Operations								
Enlarge Pine Flat Dam	3	2	3	4	3	2	**17**	**H**
Enlarge Lake Kaweah (Terminus Dam)	4	4	3	4	3	3	**21**	**H**
Groundwater/Conjunctive Use								
City of Clovis Expansion of Recharge Facilities	4	2	4	3	4	0	**17**	**H**
Kern Water Bank Authority Recharge Facilities	4	4	3	3	4	0	**18**	**H**
Kern Delta Water District Recharge Facility	4	4	3	3	4	0	**18**	**H**
Buena Vista Water Storage District Water Banking Project	4	4	3	4	3	0	**18**	**H**
Cawelo Water District Water Banking Project	4	4	4	4	4	0	**20**	**H**
Water Transfers/Banking/Exchange								
SCVWD/Delta Mendota Authority	4	4	4	4	3	0	**19**	**H**
Statewide Options								
Westside Land Retirement (30,000 acres)	4	4	4	2	1	1	**16**	**M**
Westside Land Retirement (85,000 acres)	4	4	4	2	1	1	**16**	**M**
CALFED Bay-Delta Program	3	1	2	2	3	4	**15**	**M**
SWP Interim South Delta Program	4	3	3	2	3	1	**16**	**M**
SWP Supplemental Water Purchase Program	2	3	2	2	2	0	**11**	**L**

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Drought Water Bank	4	3	3	4	3	1	**18**	**H**
Enlarge Shasta Lake	3	1	2	2	2	2	**12**	**M**
CVPIA Water Acquisition Program	4	3	3	3	2	0	**15**	**M**

Appendix 9A.

Table 9A-1.
Options Evaluation
North Lahontan Region

Option	*Evaluation Scores*							
	Engineering	*Economics*	*Environmental*	*Institutional /Legal*	*Social/Third Party*	*Other Benefits*	*Overall Score*	*Rank*
Groundwater/Conjunctive Use								
Agricultural Groundwater Development	3	1	3	3	3	0	13	M

Table 9A-2.
Options Evaluation
South Lahontan Region

Option	Evaluation Scores							Rank
	Engineering	*Economics*	*Environmental*	*Institutional /Legal*	*Social/Third Party*	*Other Benefits*	*Overall Score*	
Water Transfers/Banking/Exchange								
Mojave Water Agency	3	3	4	4	3	0	17	H
Palmdale Water District	3	3	4	4	3	0	17	H
Statewide Options								
CALFED Bay Delta Program	3	1	2	2	3	4	15	M
SWP Interim South Delta Program	4	3	3	2	3	1	16	M
SWP American Basin Conjunctive Use Program	3	4	3	2	2	3	17	H
SWP Supplemental Water Purchase Program	2	3	2	2	2	0	11	L
Enlarge Shasta Lake	3	1	2	2	2	2	12	M

Table 9A-3.
Options Evaluation
Colorado River Region[1]

Option	Evaluation Scores							
	Engineering	Economics	Environmental	Institutional/ Legal	Social/ Third Party	Other Benefits	Overall Score	Rank
Conservation								
Urban								
Outdoor Water Use - New Development	3	2	4	3	3	1	16	M
Outdoor Water Use - New and Existing Development	3	1	4	1	1	1	11	L
Residential Indoor Water Use (70gpcd)	3	2	4	3	3	1	16	M
Residential Indoor Water Use (65gpcd)	2	2	4	2	2	1	13	M
Interior CII Water Use (2%)	2	2	4	2	2	1	13	M
Interior CII Water Use(3%)	2	1	4	2	1	1	11	L
Agricultural[2]								
Irrigation Efficiency Improvements (76%)	4	4	2	4	3	1	18	H
Irrigation Efficiency Improvements (78%)	3	3	2	3	2	1	14	M
Irrigation Efficiency Improvements (80%)	3	2	2	3	2	1	13	M
Flexible Water Delivery	3	0	2	3	3	1	12	M
Canal Lining and Piping	3	0	2	3	3	1	12	M
Tailwater Recovery	3	4	2	3	3	1	16	M
Water Transfers/Banking/Exchange								
Interstate Banking	2	3	4	0	3	0	12	M
Land Fallowing Program	3	3	4	3	2	1	16	M
Other Local Options								
Lining the All American Canal / Well Fields	3	3	4	2	4	3	19	H
Additional Lining of Coachella Canal	3	3	4	2	4	3	19	H

Appendix Table 9A-3. Options Evaluation Colorado River Region[1] (cont.)

Statewide Options								
CALFED Bay - Delta Program	3	1	2	2	3	4	15	M
SWP Interim South Delta Program	4	3	3	2	3	1	16	M
SWP Supplemental Water Purchase Program	2	3	2	2	2	0	11	L
Enlarge Shasta Lake	3	1	2	2	2	2	12	M

1 Options to meet South Coast Shortages

2 Implementability subject to environmental impact review on Salton Sea

Appendix 10A. Water Budgets

The following tables show the water budgets for each of the State's ten hydrologic regions, first with no future water management options, and then with implementation of future options.

Table 10A-1.
North Coast Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.169	0.177	0.201	0.212
Agriculture	0.894	0.973	0.927	1.011
Environmental	19.544	9.518	19.545	9.518
Total Demands	20.61	10.67	20.67	10.74
Supplies				
Surface Water	20.331	10.183	20.371	10.212
Groundwater	0.263	0.294	0.288	0.321
Recycled & Desal	0.013	0.014	0.013	0.014
Total Supplies	20.61	10.49	20.67	10.55
Demands minus Supplies (Shortage)	0.00	0.18	0.00	0.19

Table 10A-2.
San Francisco Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	1.255	1.358	1.317	1.428
Agriculture	0.098	0.108	0.098	0.108
Environmental	5.762	4.294	5.762	4.294
Total Demands	7.12	5.76	7.18	5.83
Supplies				
Surface Water	7.011	5.285	7.067	5.328
Groundwater	0.068	0.092	0.074	0.091
Recycled & Desal	0.035	0.035	0.035	0.035
Total Supplies	7.12	5.41	7.18	5.45
Demands minus Supplies (Shortage)	0.00	0.35	0.00	0.38

Table 10A-3.
Central Coast Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.286	0.294	0.379	0.391
Agriculture	1.192	1.279	1.127	1.223
Environmental	0.108	0.027	0.108	0.027
Total Demands	1.58	1.60	1.61	1.64
Supplies				
Surface Water	0.308	0.150	0.367	0.183
Groundwater	1.045	1.142	1.029	1.145
Recycled & Desal	0.018	0.026	0.042	0.042
Total Supplies	1.37	1.32	1.44	1.37
Demands minus Supplies (Shortage)	0.21	0.28	0.17	0.27

Table 10A-4.
South Coast Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	4.340	4.382	5.519	5.612
Agriculture	0.784	0.820	0.462	0.484
Environmental	0.031	0.031	0.035	0.035
Total Demands	5.15	5.23	6.02	6.13
Supplies				
Surface Water	3.770	3.085	3.764	3.084
Groundwater	1.177	1.371	1.196	1.422
Recycled & Desal	0.207	0.207	0.328	0.328
Total Supplies	5.15	4.66	5.29	4.83
Demands minus Supplies (Shortage)	0.00	0.57	0.73	1.30

Table 10A-5.
Sacramento River Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.766	0.830	1.139	1.236
Agriculture	8.065	9.054	7.939	8.822
Environmental	5.825	4.222	5.951	4.344
Total Demands	14.66	14.11	15.03	14.40
Supplies				
Surface Water	11.873	10.021	12.188	10.011
Groundwater	2.672	3.218	2.636	3.281
Recycled & Desal	0.000	0.000	0.000	0.000
Total Supplies	14.55	13.24	14.82	13.29
Demands minus Supplies (Shortage)	0.11	0.87	0.21	1.11

Table 10A-6.
San Joaquin River Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.574	0.583	0.954	0.970
Agriculture	7.027	7.244	6.450	6.719
Environmental	2.302	1.420	3.087	2.205
Total Demands	9.90	9.25	10.49	9.89
Supplies				
Surface Water	7.468	5.559	7.364	5.502
Groundwater	2.195	2.900	2.323	2.912
Recycled & Desal	0.000	0.000	0.000	0.000
Total Supplies	9.66	8.46	9.69	8.41
Demands minus Supplies (Shortage)	0.24	0.79	0.80	1.48

Table 10A-7. Tulare Lake Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.690	0.690	1.099	1.099
Agriculture	10.736	10.026	10.123	9.532
Environmental	1.752	0.827	1.771	0.846
Total Demands	13.18	11.54	12.99	11.48
Supplies				
Surface Water	7.968	3.711	7.871	3.611
Groundwater	4.340	5.970	4.386	5.999
Recycled & Desal	0.000	0.000	0.000	0.000
Total Supplies	12.31	9.68	12.26	9.61
Demands minus Supplies (Shortage)	0.87	1.86	0.73	1.87

Table 10A-8. North Lahontan Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.039	0.040	0.050	0.051
Agriculture	0.530	0.584	0.536	0.594
Environmental	0.635	0.341	0.635	0.341
Total Demands	1.20	0.97	1.22	0.99
Supplies				
Surface Water	1.038	0.642	1.020	0.642
Groundwater	0.157	0.187	0.183	0.208
Recycled & Desal	0.008	0.008	0.008	0.008
Total Supplies	1.20	0.84	1.21	0.86
Demands minus Supplies (Shortage)	0.00	0.13	0.01	0.13

Table 10A-9.
South Lahontan Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.238	0.238	0.619	0.619
Agriculture	0.332	0.332	0.257	0.257
Environmental	0.107	0.081	0.107	0.081
Total Demands	0.68	0.65	0.98	0.96
Supplies				
Surface Water	0.322	0.259	0.545	0.441
Groundwater	0.239	0.273	0.227	0.279
Recycled & Desal	0.027	0.027	0.027	0.027
Total Supplies	0.59	0.56	0.80	0.75
Demands minus Supplies (Shortage)	0.09	0.09	0.18	0.21

Table 10A-10.
Colorado River Region Water Budget with Existing Facilities & Programs (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.418	0.418	0.740	0.740
Agriculture	4.118	4.118	3.583	3.583
Environmental	0.039	0.038	0.044	0.043
Total Demands	4.58	4.57	4.37	4.37
Supplies				
Surface Water	4.154	4.128	4.023	4.013
Groundwater	0.337	0.337	0.251	0.250
Recycled & Desal	0.015	0.015	0.015	0.015
Total Supplies	4.51	4.48	4.29	4.28
Demands minus Supplies (Shortage)	0.07	0.09	0.08	0.09

Table 10A-11.
North Coast Region Water Budget with Recommended Options
(maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.169	0.177	0.201	0.212
Agriculture	0.894	0.973	0.927	1.011
Environmental	19.544	9.518	19.545	9.518
Management Options	------	------	(-0.000)	(-0.004)
Total Demands	20.61	10.67	20.67	10.74
Supplies				
Surface Water	20.331	10.183	20.371	10.212
Groundwater	0.263	0.294	0.288	0.321
Recycled & Desal	0.013	0.014	0.013	0.014
Augmentation Options	-----	-----	------	------
Total Supplies	20.61	10.49	20.67	10.55
Demands minus Supplies (Shortage)	0.00	0.18	0.00	0.19

Table 10A-12.
San Francisco Region Water Budget with Recommended Options
(maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	1.255	1.358	1.317	1.428
Agriculture	0.098	0.108	0.098	0.108
Environmental	5.762	4.294	5.762	4.294
Management Options	----	----	-----	(-0.032)
Total Demands	7.12	5.76	7.18	5.80
Supplies				
Surface Water	7.011	5.285	7.067	5.328
Groundwater	0.068	0.092	0.074	0.091
Recycled & Desal	0.035	0.035	0.035	0.035
Augmentation Options	----	----	-----	0.273
Total Supplies	7.12	5.41	7.18	5.73
Demands minus Supplies (Shortage)	0.00	0.35	0.00	0.07

Table 10A-13.
Central Coast Region Water Budget with Recommended Options
(maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.286	0.294	0.379	0.391
Agriculture	1.192	1.279	1.127	1.223
Environmental	0.108	0.027	0.108	0.027
Management Options	-----	-----	(-0.010)	(-0.010)
Total Demands	1.58	1.60	1.60	1.63
Supplies				
Surface Water	0.308	0.150	0.367	0.183
Groundwater	1.045	1.142	1.029	1.145
Recycled & Desal	0.018	0.026	0.042	0.042
Augmentation Options	-----	-----	0.133	0.093
Total Supplies	1.37	1.32	1.57	1.46
Demands minus Supplies (Shortage)	0.21	0.28	0.03	0.17

Table 10A-14.
South Coast Region Water Budget with Recommended Options
(maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	4.340	4.382	5.519	5.612
Agriculture	0.784	0.820	0.462	0.484
Environmental	0.031	0.031	0.035	0.035
Management Options	----	----	(-0.090)	(-0.090)
Total Demands	5.15	5.23	5.93	6.04
Supplies				
Surface Water	3.770	3.085	3.764	3.084
Groundwater	1.177	1.371	1.196	1.422
Recycled & Desal	0.207	0.207	0.328	0.328
Augmentation Options	-----	-----	0.638	1.180
Total Supplies	5.15	4.66	5.93	6.01
Demands minus Supplies (Shortage)	0.00	0.57	0.00	0.03

Table 10A-15
Sacramento River Region Water Budget with Recommended Options (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.766	0.830	1.139	1.236
Agriculture	8.065	9.054	7.939	8.822
Environmental	5.825	4.222	5.951	4.344
Management Options	-----	-----	-----	-----
Total Demands	14.66	14.11	15.03	14.40
Supplies				
Surface Water	11.873	10.021	12.188	10.011
Groundwater	2.672	3.218	2.636	3.281
Recycled & Desal	0.000	0.000	0.000	0.000
Augmentation Options	-----	-----	0.206	0.329
Total Supplies	14.55	13.24	15.03	13.62
Demands minus Supplies (Shortage)	0.11	0.87	0.00	0.78

Table 10A-16.
San Joaquin River Region Water Budget with Recommended Options (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.574	0.583	0.954	0.970
Agriculture	7.027	7.244	6.450	6.719
Environmental	2.302	1.420	3.087	2.205
Management Options	-----	-----	(-0.002)	(-0.002)
Total Demands	9.90	9.25	10.49	9.89
Supplies				
Surface Water	7.468	5.559	7.364	5.502
Groundwater	2.195	2.900	2.323	2.912
Recycled & Desal	0.000	0.000	0.000	0.000
Augmentation Options	-----	-----	0.035	0.110
Total Supplies	9.66	8.46	9.72	8.52
Demands minus Supplies (Shortage)	0.24	0.79	0.77	1.37

Table 10A-17.
Tulare Lake Region Water Budget with Recommended Options
(maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.690	0.690	1.099	1.099
Agriculture	10.736	10.026	10.123	9.532
Environmental	1.752	0.827	1.771	0.846
Management Options	-----	-----	(-0.075)	(-0.075)
Total Demands	13.18	11.54	12.92	11.40
Supplies				
Surface Water	7.968	3.711	7.871	3.611
Groundwater	4.340	5.970	4.386	5.999
Recycled & Desal	0.000	0.000	0.000	0.000
Augmentation Options	-----	-----	0.251	0.760
Total Supplies	12.31	9.68	12.51	10.37
Demands minus Supplies (Shortage)	0.87	1.86	0.41	1.03

Table 10A-18.
North Lahontan Region Water Budget with Recommended Options
(maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.039	0.040	0.050	0.051
Agriculture	0.530	0.584	0.536	0.594
Environmental	0.635	0.341	0.635	0.341
Management Options	-----	-----	-----	-----
Total Demands	1.20	0.97	1.22	0.99
Supplies				
Surface Water	1.038	0.642	1.020	0.642
Groundwater	0.157	0.187	0.183	0.208
Recycled & Desal	0.008	0.008	0.008	0.008
Augmentation Options	-----	-----	-----	-----
Total Supplies	1.20	0.84	1.21	0.86
Demands minus Supplies (Shortage)	0.00	0.13	0.01	0.13

Table 10A-19.
South Lahontan Region Water Budget with Recommended Options (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.238	0.238	0.619	0.619
Agriculture	0.332	0.332	0.257	0.257
Environmental	0.107	0.081	0.107	0.081
Management Options	-----	-----	-----	-----
Total Demands	0.68	0.65	0.98	0.96
Supplies				
Surface Water	0.322	0.259	0.545	0.441
Groundwater	0.239	0.273	0.227	0.279
Recycled & Desal	0.027	0.027	0.027	0.027
Augmentation Options	-----	-----	0.025	0.030
Total Supplies	0.59	0.56	0.82	0.78
Demands minus Supplies (Shortage)	0.09	0.09	0.16	0.18

Table 10A-20.
Colorado River Region Water Budget with Recommended Options (maf)

Demands & Supplies	1995		2020	
	Average	Drought	Average	Drought
Demands				
Urban	0.418	0.418	0.740	0.740
Agriculture	4.118	4.118	3.583	3.583
Environmental	0.039	0.038	0.044	0.043
Management Options	-----	-----	(-0.326)	(-0.326)
Total Demands	4.58	4.57	4.04	4.04
Supplies				
Surface Water	4.154	4.128	4.023	4.013
Groundwater	0.337	0.337	0.251	0.250
Recycled & Desal	0.015	0.015	0.015	0.015
Augmentation Options	-----	-----	(-0.247) (*)	(-0.238) (**)
Total Supplies	4.51	4.48	4.04	4.04
Demands minus Supplies (Shortage)	0.07	0.09	0.00	0.00

(*) 252 taf of Colorado River supplies would be transferred to the South Coast Region in average years as part of the Colorado River 4.4 Plan

(**) 343 taf of Colorado River supplies would be transferred to the South Coast Region in drought years as part of the Colorado River 4.4 Plan. (The 4.4 Plan also includes 50 taf of banked water from Arizona in drought years, for a total transfer to the South Coast Region of 393 taf per year.)

Abbreviations and Acronyms

AB Assembly Bill

AAC All American Canal

ACFC&WCD Alameda County Flood Control and Water Conservation District, Zone 7

ACID Anderson-Cottonwood Irrigation District

ACWD Alameda County Water District

AD Allowable Depletion

ADWR Arizona Department of Water Resources

AEWSD Arvin-Edison Water Storage District

af acre-feet

AFRP Anadromous Fish Restoration Program (or Plan)

AFSP Anadromous Fish Screening Program

AMD acid mine drainage

AOP advanced oxidation process

ARP aquifer reclamation project

ASR aquifer storage and recovery

AVEK Antelope Valley East Kern Water Agency

AVWG Antelope Valley Water Group

AW applied water

AWRI American River water resources investigation

BARWRP Bay Area Regional Water Recycling Program

BAT	best available technology
BBID	Byron-Bethany Irrigation District
BDAC	Bay-Delta Advisory Council
BLM	Bureau of Land Management
BMP	Best Management Practice
BVWSD	Buena Vista Water Storage District
BWD	Bard Water District
BWRDF	Brackish Water Reclamation Demonstration Facility

Cal-Am	California-American Water Company
CALFED	State (CAL) and federal (FED) agencies participating in Bay-Delta Accord
CAP	Central Arizona Project
CCMP	Comprehensive Consevation and Management Plan
CCRWR	Central California Regional Water Recycling Project
CCWD	Contra Costa Water District
CDI	captive deionization
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	Cubic feet per second
CII	Commercial, Industrial, and Institutional
CIMIS	California Irrigation Management Information System
COA	Coordinated Operation Agreement
COG	Council of Governments

CMO Crop Market Outlook

CPUC California Public Utilities Commission

CRA Colorado River Aqueduct

CRB Colorado River Board

CRIT Colorado River Indian Tribes

CSD Community Services District

CSIP/SVRP Castroville Seawater Intrusion Project/Salinas Valley Reclamation Project

CSJWCD Central San Joaquin Water Conservation District

CUWCC California Urban Water Conservation Council

CVHJV Central Valley Habitat Joint Venture

CVP Central Valley Project

CVPIA Central Valley Project Improvement Act

CVPM Central Valley Production Model

CVWD Coachella Valley Water District

CWA Clean Water Act

CWSC California Water Service Company

D-1485 State Water Resources Control Board Water Right Decision 1485

DAU detailed analysis unit

DBCP dibromochloropropane

DBP disinfection byproduct

D/DBP disinfectant/disinfection by-product

DFA California Department of Food and Agriculture

DFG	California Department of Fish and Game
DHS	California Department of Health Services
DOE	Department of Energy
DOF	California Department of Finance
DOI	Department of the Interior
DU	distribution uniformity
DWA	Desert Water Agency
DWB	Drought Water Bank
DWD	Diablo Water District
DWR	California Department of Water Resources
DWRSIM	DWR's operations model for SWP/CVP system
DWSRF	Drinking Water State Revolving Fund

EBMUD	East Bay Municipal Utility District
ECCID	East Contra Costa Irrigation District
ECWMA	East County Water Management Association
ED	electrodialysis
EDB	ethylene dibromide
EDCWA	El Dorado County Water Agency
EDF	Environmental Defense Fund
EDR	electrodialysis reversal
EID	El Dorado Irrigation District
EIR	Environmental Impact Report

EIS Environmental Impact Statement

EPA Environmental Protection Agency

ERPP Ecosystem Restoration Program Plan

ESA Endangered Species Act

ESU evolutionarily significant unit

ESWTR Enhanced Surface Water Treatment Rule

ET evapotranspiration

ET_o reference evapotranspiration

ETAW evapotranspiration of applied water

EWMP Efficient Water Management Practice

FERC Federal Energy Regulatory Commission

FY Fiscal Year

GAC Granular Activated Carbon

GBUAPCD Great Basin Unified Air Pollution Control District

GCID Glenn-Colusa Irrigation District

GDPUD Georgetown Divide Public Utility District

GO general obligation

gpcd gallons per capita daily

GPF gallons per flush

HLWA	Honey Lake Wildlife Area
HR	Hydrologic region
IBWC	International Boundary and Water Commission
ID	irrigation district or improvement district
IE	irrigation efficiency
IEP	Interagency Ecological Program
IID	Imperial Irrigation District
IOT	intake opportunity time
IRP	integrated resources planning
ISDP	Interim South Delta Program
JPA	Joint Powers Authority
KCWA	Kern County Water Agency
KPOP	Klamath Project Operations Plan
KWB	Kern Water Bank
LAA	Los Angeles Aqueduct
LADWP	Los Angeles Department of Water and Power
LBG	Los Banos Grandes
LCRMSCP	Lower Colorado Multi-Species Conservation Program

LEPA low-energy precision application

LRWQCB Lahontan Regional Water Quality Control Board

LTBMU Lake Tahoe Basin Management Unit

maf million acre-feet

MCL maximum contaminant level

MCWD Marina Coast Water District or Mammoth Community Water District

MCWRA Monterey County Water Resources Agency

MF microfiltration

mgd million gallons per day

M&I municipal & industrial

MID Merced Irrigation District or Modesto Irrigation District

MMWC McFarland Mutual Water Company

MMWD Marin Municipal Water District

MOU memorandum of understanding

MPWMD Monterey Peninsula Water Management District

MRWPCA Monterey Regional Water Pollution Control Agency

MTBE methyl tertiary butyl ether

MWA Mojave Water Agency

MWDOC Municipal Water District of Orange County

MWDSC Metropolitan Water District of Southern California

NAWMP North American Waterfowl Management Plan

NCFC&WDC Napa County Flood Control and Water Conservation District

NCMWC Natomas-Central Mutual Water Company

NED National Economic Development

NEPA National Environmental Policy Act

NF nanofiltration

NGO non-governmental organizations

NID Nevada Irrigation District

NISA National Invasive Species Act

NMFS National Marine Fisheries Service

NOP notice of preparation

NPDES National Pollutant Discharge Elimination System

NPDRW national primary drinking water regulations

NRCS National Resources Conservation Service

NWR National Wildlife Refuge

OCWD Orange County Water District

OID Oakdale Irrigation District

PAC powdered activated carbon

PCE perchlorethylene

PCWA Placer County Water Agency

PEIS Programmatic Environmental Impact Statement

PG&E Pacific Gas and Electric Company

PGVMWC Pleasant Grove-Verona Mutual Water Company

P.L. Public Law

ppb parts per billion

PROSIM USBR's operations model for the CVP/SWP

PSA planning subarea

PUC public utility commission

PUD public utility district

PVID Palo Verde Irrigation District or Pleasant Valley Irrigation District

PVWMA Pajaro Valley Water Management Agency

PWD Palmdale Water District

RBDD Red Bluff Diversion Dam

RCD resource conservation district

RD reclamation district

RDI regulated deficit irrigation

RO reverse osmosis

RWQCB Regional Water Quality Control Board

SAE seasonal application efficiency

SAFCA Sacramento Area Flood Control Agency

SAWPA Santa Ana Watershed Project

SB Senate Bill

SBCFCWCD Santa Barbara County Flood Control and Water Conservation District

SBVMWD San Bernardino Valley Municipal Water District

SCCWRRS Southern California Comprehensive Water Reclamation and Reuse Study

SCE Southern California Edison

SCVWD Santa Clara Valley Water District

SCWA Solano County Water Agency or Sonoma County Water Agency

SDCWA San Diego County Water Authority

SDWA South Delta Water Agency or Safe Drinking Water Act

SEIS Supplemental Environmental Impact Statement

SEWD Stockton East Water District

SFAR South Fork American River (project)

SFBJV San Francisco Bay Joint Venture

SFEP San Francisco Estuary Project

SFPUC San Francisco Public Utility Commission

SFWD San Francisco Water District

SGPWA San Gorgonio Pass Water Agency

SID Solano Irrigation District

SJR San Joaquin River

SJRMP San Joaquin River Management Plan (or Program)

SJRIODAY San Joaquin River Input-Output Model, adapted to a daily time-step

SJVDP San Joaquin Valley Drainage Program

SLC San Luis Canal

SLD San Luis Drain

SLDMWA San Luis & Delta-Mendota Water Authority

SLOCFC&WCD San Luis Obispo County Flood Control and Water Conservation District

SMBRP Santa Monica Bay Restoration Project

SNWA Southern Nevada Water Authority

SOC synthetic organic chemical

SRF state revolving fund

SRFCP Sacramento River Flood Control Project

SRI Sacramento River Index

SRWP Sacramento River Watershed Program

SSA Salton Sea Authority

SSJID South San Joaquin Irrigation District

SSWD South Sutter Water District

STPUD South Tahoe Public Utility District

SVGMD Sierra Valley Groundwater Management District

SVOC semi-volatile organic compound

SWF Sacramento Water Forum

SWP State Water Project

SWPP source water protection program, or supplemental water purchase program

SWRCB State Water Resources Control Board

SWSD Semitropic Water Storage District

taf thousand acre-feet

TCC Tehama-Colusa Canal

TCD temperature control device

TCE	trichlorethylene
TDS	total dissolved solids
THM	trihalomethane
TID-MID	Turlock Irrigation District and Modesto Irrigation District
TROA	Truckee River Operating Agreement
TRPA	Tahoe Regional Planning Agency
UCD	University of California at Davis
UF	ultrafiltration
USBR	U.S. Bureau of Reclamation
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UVOX	ultraviolet/hydrogen peroxide
VOC	volatile organic compound
W&S	Wild and Scenic
WCB	Wildlife Conservation Board
WMI	Watershed Management Initative
WMA	state wildlife management area
WQA	Water Quality Authority

WQCP water quality control plan

WRDA Water Resources Development Act

WRID Walker River Irrigation District

WSD water storage district

WSMP water storage management plan (or program)

WWD Westlands Water District

WWTP waste water treatment plant

WWW Worldwide Web

YCFCWCD Yolo County Flood Control and Water Conservation District

YCWA Yuba County Water Agency

Glossary

active storage capacity the total usable reservoir capacity available for seasonal or cyclic water storage. It is gross reservoir capacity minus inactive storage capacity.

afterbay a reservoir that regulates fluctuating discharges from a hydroelectric power plant or a pumping plant.

agricultural drainage (1) the process of directing excess water away from root zones by natural or artificial means, such as by using a system of pipes and drains placed below ground surface level; also called subsurface drainage; (2) the water drained away from irrigated farmland.

alluvium unconsolidated soil strata deposited by flowing water.

anadromous fish that spend a part of their life cycle in the sea and return to freshwater streams to spawn.

applied water demand the quantity of water delivered to the intake of a city's water system or factory, the farm headgate or other point of measurement, or a marsh or other wetland, either directly or by incidental drainage flows. For instream use, it is the portion of the stream flow dedicated to instream use or reserved under the federal or State Wild and Scenic Rivers acts.

aquifer a geologic formation that stores water and yields significant quantities of water to wells or springs.

arid a term describing a climate or region in which precipitation is so deficient in quantity or occurs so infrequently that intensive agricultural production is not possible without irrigation.

artificial recharge addition of surface water to a groundwater reservoir by human activity, such as putting surface water into spreading basins. See also *groundwater recharge, recharge basin.*

average annual runoff for a specified area is the average value of annual runoff volume calculated for a selected period of record, at a specified location, such as a dam or stream gage.

average year water demand demand for water under average hydrologic conditions for a defined level of development.

best management practice (BMP) a generally accepted practice for some aspect of natural resources management, such as water conservation measures, drainage management measures, or erosion control measures. Most frequently used in this Bulletin to refer to water conservation measures adopted by the California Urban Water Conservation Coalition.

biota all living organisms of a region, as in a stream or other body of water.

brackish water water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses. Considerably less saline than sea water.

bromide a salt which naturally occurs in small quantities in sea water; a compound of bromine.

chaparral a major vegetation type in California characterized by dense evergreen shrubs with thick, hardened leaves.

closed basin a basin whose topography prevents surface outflow of water.

confined aquifer a water-bearing subsurface stratum that is bounded above and below by formations of impermeable, or relatively impermeable, soil or rock.

conjunctive use the operation of a groundwater basin in combination with a surface water storage and conveyance system. Water is stored in the groundwater basin for later use by intentionally recharging the basin during years of above-average water supply.

Decision 1485 operating criteria standards for operating the CVP and SWP under Water Right Decision 1485 for the Sacramento-San Joaquin Delta and Suisun Marsh, adopted by the State Water Resources Control Board in August 1978.

Decision 1631 a water right decision specifying required Mono Lake levels, adopted by the State Water Resources Control Board in 1994.

deep percolation the percolation of water through the ground and beyond the lower limit of the root zone of plants into groundwater.

demand management alternatives water management programs–such as water conservation or drought rationing that reduce demand for water.

dependable supply the average annual quantity of water that can be delivered during a drought period.

depletion the water consumed within a service area and no longer available as a source of supply. For agriculture and wetlands, it is ETAW (and ET of flooded wetlands) plus irrecoverable losses. For urban water use, it is ETAW (water applied to landscaping or home gardens), sewage effluent that flows to a salt sink, and incidental ET losses. For instream use, it is the amount of dedicated flow that reaches a salt sink.

desalination a process to reduce the salt concentration of sea water or brackish water; also called *desalting.*

detailed analysis unit (DAU) the smallest study area used by Department of Water Resources for analyses of water demand and supply. Generally defined by hydrologic features or boundaries of

organized water service agencies. In the major agricultural areas, a DAU typically includes 100,000 to 300,000 acres.

discount rate the interest rate used to calculate the present value of future benefits and future costs or to convert benefits and costs to a common time basis.

dissolved organic compounds carbon-based substances dissolved in water.

dissolved oxygen (DO) the amount of oxygen dissolved in water or wastewater, usually expressed in milligrams per liter, parts per million, or percent of saturation.

distribution uniformity (DU) A measure of the variation in the amount of water applied to the soil surface throughout an irrigated area, expressed as a percent.

drainage basin the area of land from which water drains into a river; for example, the Sacramento River Basin, in which all land area drains into the Sacramento River. Also called, "catchment area", "watershed", or "river basin".

drought condition hydrologic conditions during a defined period when rainfall and runoff are much less than average.

drought year supply the average annual supply of a water development system during a defined drought period.

efficient water management practice (EWMP) an agricultural water conservation measure, such as those adopted under the 1996 MOU regarding agricultural water conservation.

effluent wastewater or other liquid, treated or in its natural state, flowing from a treatment plant or process.

environmental water the water for wetlands, for the instream flow in a major river or in the Bay-Delta, or for a designated wild and scenic river

estuary the lower course of a river entering the sea where the tides meet river current.

evapotranspiration (ET) the quantity of water transpired (given off), retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces.

evapotranspiration of applied water (ETAW) the portion of the total evapotranspiration which is provided by irrigation and landscape watering.

firm yield the maximum annual supply from of a water development project under drought conditions, for some specified level of demands.

forebay a reservoir at the intake of a pumping plant or power plant to stabilize water levels; also a storage basin for regulating water for percolation into groundwater basins.

fry a recently hatched fish.

gray water waste water from a household or small commercial establishment. Gray water *does not* include water from a toilet, kitchen sink, dishwasher, washing machine, or water used for washing diapers, etc.

gross reservoir capacity the total storage capacity available in a reservoir for all purposes, from the streambed to the normal maximum operating level. Includes dead (or inactive) storage, but excludes surcharge (water temporarily stored above the elevation of the top of the spillway).

groundwater water that occurs beneath the land surface and fills the pore spaces of the alluvium, soil, or rock formation in which it is situated.

groundwater basin a groundwater reservoir, defined by an overlying land surface and the underlying aquifers that contain water stored in the reservoir. In some cases, the boundaries of successively deeper aquifers may differ and make it difficult to define the limits of the basin.

groundwater overdraft the condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions.

groundwater recharge increases in groundwater storage by natural conditions or by human activity. See also *artificial recharge*.

groundwater storage capacity volume of void space that can be occupied by water in a given volume of a formation, aquifer, or groundwater basin.

groundwater table the upper surface of the zone of saturation, in an unconfined aquifer.

hardpan a layer of nearly impermeable soil beneath a more permeable soil, formed by natural chemical cementation of the soil particles.

head ditch the water supply ditch at the head of an irrigated field.

hydraulic barrier a barrier developed in an estuary by release of fresh water from upstream reservoirs to prevent intrusion of a sea water into the body of fresh water. Also, a barrier created by injecting fresh water to control seawater intrusion in an aquifer, or created by water injection to control migration of contaminants in an aquifer.

hydrologic balance an accounting of all water inflow to, water outflow from, and changes in water storage within a hydrologic unit over a specified period of time.

hydrologic basin the drainage area upstream from a given point on a stream.

hydrologic region a study area, consisting of one or more planning subareas. California is divided into 10 hydrologic regions.

instream use use of water within its natural watercourse as specified in an agreement, water rights permit, etc. For example, the use of water for navigation, recreation, fish and wildlife, aesthetics, and scenic enjoyment.

irrecoverable losses the water lost to a salt sink or lost by evaporation or evapotranspiration from a conveyance facility or drainage canal, or in fringe areas of cultivated fields.

irrigated acreage land area that is irrigated, which is equivalent to total irrigated crop acreage minus the amount of acreage that was multiple-cropped.

irrigation efficiency the efficiency of water application and use. Computed by dividing evapotranspiration of applied water by applied water and converting the result to a percentage. Efficiency can be computed at three levels: farm, district, or basin.

irrigation return flow applied water that is not transpired, evaporated, or infiltrated into a groundwater basin but that returns to a surface water body.

land retirement (as used in this report) taking land out of irrigated agricultural use as part of a managed incentive program.

land subsidence the lowering of the natural land surface due to groundwater (or oil and gas) extraction.

laser land leveling precision leveling of cultivated fields to improve irrigation efficiency.

laterals the part of an irrigation districts's delivery system that conveys water from the district's main canals to turnouts for farmers' fields

leaching the flushing of salts from the soil by the downward percolation of applied water.

leaching requirement the theoretical amount of irrigation water that must pass (leach) through the soil beyond the root zone to keep soil salinity within acceptable levels for sustained crop growth.

level of development in a planning study, the practice of holding water demands constant at some specified level so that hydrologic variability can be studied.

maximum contaminant level (MCL) the highest concentration of a contaminant in drinking water permitted under federal and State Safe Drinking Water Act regulations.

moisture stress a condition of physiological stress in a plant caused by lack of water.

multipurpose project a project, usually a reservoir, designed to serve more than one purpose. For example, one that provides water supply and also provides flood control or generates hydroelectricity.

National Pollutant Discharge Elimination System (NPDES) a provision of Section 402 of the federal Clean Water Act that established a permitting system for discharges of waste materials to water courses.

natural flow the flow past a specified point on a natural stream that is unaffected by stream diversion, storage, import, export, return flow, or change in use caused by modifications in land use.

net water demand (net water use) the amount of water needed in a water service area to meet all requirements. It is the sum of evapotranspiration of applied water in an area, the irrecoverable losses from the distribution system, and the outflow leaving the service area; does not include reuse of water within a service area.

nonpoint source waste water discharge other than from point sources. See also *point source*.

nonreimbursable costs the part of project costs allocated to general statewide or national beneficial purposes and funded from general revenues, rather than to water users.

normalized demand the process of adjusting actual water use in a given year to account for unusual events such as dry weather conditions, government price support programs for agriculture, rationing programs, or other unusual conditions.

overdraft See *groundwater overdraft*.

pathogens viruses, bacteria, or fungi that cause disease.

perched groundwater groundwater supported by a zone of material of low permeability located above an underlying main body of groundwater.

per capita water use the water produced by or introduced into the system of a water supplier divided by the total residential population; normally expressed in gallons per capita per day (gpcd).

perennial yield the maximum quantity of water that can be annually withdrawn from a groundwater basin over a long period of time (during which water supply conditions approximate average conditions) without developing an overdraft condition.

permeability the capability of soil or other geologic formations to transmit water.

phytoplankton minute plants, such as algae, that live suspended in bodies of water.

planning subarea (PSA) an intermediately-sized study area used by the Department, consisting of multiple detailed analysis units.

point source a specific site from which wastewater or polluted water is discharged into a water body.

pollution (of water) the alteration of the physical, chemical, or biological properties of water by the introduction of any substance into water that adversely affects any beneficial use of water.

project yield the water supply attributed to all features of a project, including integrated operation of units that could be operated individually.

pump lift the distance between the groundwater table and the overlying land surface.

pumped storage project a hydroelectric powerplant and reservoir system using an arrangement whereby water released for generating energy during peak load periods is stored and pumped back into the upper reservoir, usually during periods of reduced power demand.

pumping-generating plant a plant at which the turbine-driven generators can also be used as motor-driven pumps.

recharge basin a surface facility constructed to provide to infiltrate surface water into a groundwater basin.

recycled water urban wastewater that becomes suitable, as a result of treatment, for a specific beneficial use. Also called reclaimed water. See also *water recycling*.

return flow the portion of withdrawn water not consumed by evapotranspiration or system losses which returns to its source or to another body of water.

reuse the additional use of previously used water. As used in this report, it is not water that has been recycled for beneficial use at a treatment plant.

reverse osmosis is a method to remove salts from water by forcing water through membranes.

riparian located on the banks of a stream or other body of water. Riparian water rights are rights held by landowners adjacent to a natural waterbody.

runoff the volume of surface flow from an area.

salinity generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as an electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water. See also *total dissolved solids.*

salinity intrusion the movement of salt water into a body of fresh water. It can occur in either surface water or groundwater bodies.

salt sink a saline body of water, such as the ocean.

salt-water barrier a physical facility or method of operation designed to prevent the intrusion of salt water into a body of fresh water (see hydraulic barrier).

seepage the gradual movement of a fluid into, through, or from a porous medium.

self-produced water a water supply (often from wells) developed and used by an individual or entity. Also called "self-supplied water."

service area the geographic area served by a water agency.

soluble minerals naturally occurring substances capable of being dissolved.

spreading basin See *recharge basin.*

spreading grounds See *recharge basin.*

supply augmentation alternatives water management programs -- such as reservoir construction or groundwater extraction -- that increase supply.

surface supply water supply from streams, lakes, and reservoirs.

tailwater applied irrigation water that runs off the end of a field. Tail water is not necessarily lost; it can be collected and reused on the same or adjacent fields.

tertiary treatment in wastewater treatment, the additional treatment of effluent beyond that of secondary treatment to obtain higher quality of effluent for reuse.

total dissolved solids a quantitative measure of the residual minerals dissolved in water that remain after evaporation of a solution. Usually expressed in milligrams per liter. Abbreviation: TDS. See also *salinity.*

transpiration an essential physiological process in which plant tissues give off water vapor to the atmosphere.

trihalomethane (THM) a chlorinated halogen compound such as chloroform, carbon tetrachloride or bromoform.

wastewater domestic or municipal sewage or effluent from an industrial process.

water conservation reduction in applied water due to more efficient water use such as implementation of urban best management practices or agricultural efficient water management practices. The extent to which these actions actually create a savings in water supply depends on how they affect net water use and depletion.

water quality used to describe the chemical, physical, and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.

water recycling the treatment of urban wastewater to a level rendering it suitable for a specific beneficial use.

water service reliability the degree to which a water service system can successfully manage water shortages.

watershed See *drainage basin*.

water table See *groundwater table*.

water transfers the permanent sale of a water right by the water right holder; a lease of the right to use water from the water right holder; the sale or lease of a contractual right to water supply.

water year a continuous 12-month period for which hydrologic records are compiled and summarized. Different agencies may use different calendar periods for their water years.

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